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SPOKEN-WORD PROCESSING
IN CONTEXT

Colin M. Brown

SPOKEN-WORD PROCESSING IN CONTEXT

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op het gebied van de sociale wetenschappen,

in het bijzonder de psychologie

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volgens besluit van het college van decanen
in het openbaar te verdedigen
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door

Colin Michael Brown
geboren te Londen (G.B.)

Promotor: Prof. dr. W.J.M. Levelt

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... that instance which is the root of all superstition,
namely, that to the nature of the mind of all men
it is consonant for the affirmative or active
to affect more than the negative or privative.

Francis Bacon
The Advancement of Learning

1 INTRODUCTION

The appreciation of human psychology as a science (and, by implication, of psychologists as scientists) is hampered by a fundamental quality of cognition: much of the mental activity of human beings proceeds in a quietly efficient, seemingly effortless manner, submerged in the nether regions of awareness. The uninitiated might wonder, therefore, whether there actually is a problem to be investigated - let alone solved - such as the psychologists maintain. The subject of this dissertation is spoken-language comprehension, which is a prime example of a central cognitive capacity that seems not to be a problem. Brief reflection, however, reveals that language understanding is a startlingly complex process, and that it is no simple matter to give an adequate explanatory account of this uniquely human ability. The experimental programme reported here should be seen as an attempt to delineate some of the boundaries within which an explanation can be sought. I will try to constrain the interpretative framework for the comprehension process by investigating some central aspects of on-line lexical processing. Specifically, I will focus on the time-course of spoken-word recognition, on the sources of semantic information that are exploited during comprehension, and on the locus of the effects of such information within the word-recognition process. Before turning to details, I will provide a sketch in general terms of the language comprehension process.

Normal conversational speech is uttered at a rate of some two to three words per second, and it is understood with no appreciable time lag. Although it is not known how many words the average adult listener has actively available, conservative estimates are in the 30.000 to 50.000 range (cf. Aitchison, 1987; Nagy & Herman, 1987). What this implies, is that in an everyday conversational setting a listener selects a single word from within a set of some 40.000 words, in a time period of less than half a second (note that this by no means reflects a performance limit: utterances can be produced - and understood - at much higher rates). This rapid selection does not stand on its own, but is a part - a central one as we shall see - of the overall comprehension process. Not only are the individual words of an utterance reliably and rapidly identified from within a continuous stream of speech, but the intended message is likewise efficiently extracted from this sequence of transient sounds. A sentence comprising some ten words will typically be produced within three seconds. In this interval, the listener identifies the individual words, retrieves their meaning as well as their grammatical form, and builds up a representation of the overall sense of the utterance. In doing so, the listener has a number of different sources of knowledge available. The specifically linguistic knowledge is traditionally separated into knowledge of the sound patterns of the language, of its syntax, and of its semantics. In addition, listeners have non-linguistic knowledge available which can contribute to understanding. This is usually referred to, somewhat awkwardly, as world knowledge, or pragmatics.

Word recognition plays an important role within the comprehension process. Words are the building blocks of understanding, mediating between the sensory input and the ultimate meaning representation. The mental lexicon, therefore, is one of the most central representational systems of the language faculty. Given the evident importance of word recognition for language comprehension, much psycholinguistic research has focussed on lexical processing. The result has been a plethora of qualitatively often very different models. Consequently, it is almost impossible to characterize the word-recognition process in a neutral manner. All of the available theoretical terms have been permeated to a greater or lesser extent by the particular processing assumptions of separate models. With this cautionary note in mind, however, there is a certain amount of agreement that spoken-word recognition can be functionally dissected into lexical access, selection, and integration processes.

Lexical access is the process of computing a form-representation of some initial part of the physical signal, and of projecting this representation onto corresponding entries in the mental lexicon. The product of lexical access is a cluster of words, all of which have significant overlap with the analyzed acoustic signal. Lexical selection operates within the instantiated cluster, narrowing down the number of possible candidates for recognition until a single word remains. Lexical integration processes are concerned with entering the selected word into a higher-order meaning representation of the entire utterance.

Despite my attempts at neutrality, and despite the brevity of the previous paragraph, it nevertheless contains a number of contentious points. In particular the implicit claim that lexical selection and integration are independent functions, lies at the heart of a longstanding controversy concerning the nature and structure of the word-recognition process. The central issue here is the extent of the informational encapsulation of the word-recognition process: which sources of linguistic and non-linguistic information are thought to guide the on-line identification of words? The controversy has led to a bewildering variety of word-recognition models, which makes it increasingly difficult to provide a complete overview of the on-line models that have been proposed as explanatory frameworks for the word-recognition process. For present purposes, I will give a general account, outlining the major distinctions between different classes of models. The account focusses on the lexical selection process. In part because it is here that the differences between models are most evident. In part because work on-line lexical integration processes is underdeveloped in present psycholinguistic research and there is, therefore, little of empirical substance to be mentioned.

A broad separation can be made into autonomous and interactive models. Autonomous models assume independent levels of information processing, with each level producing an output in isolation from the information represented at other levels. Within the framework of the general functional analysis provided above, these models claim that the lexical access and selection processes proceed on the basis of bottom-up sensory information only, and that higher-level information (e.g., sentential-semantics) can only affect post-selectional operations, such as the integration of a recognized word into a higher-order discourse representation (I am somewhat simplifying matters; more subtle details concerning the possible influence of lexically represented meaning relations will be taken up in Chapter 3). Interactive models assume that information from within any level of the system can be brought to bear on the ongoing analysis of the input. Here then, the word-recognition process can and will be guided by any information that can be relevantly applied to the analysis of the incoming signal (again, I am postponing some finer shades until Chapter 3). In particular, the lexical selection process is thought to be a meeting ground for both stimulus analysis computations and higher-order informational constraints, such as derive from, for instance, pragmatics. The locus of the influence of sentential-semantic information during word recognition is, then, the foremost distinguishing characteristic of autonomous and interactive processing models. As is often the case in science, hybridous models flourish. These combine features from the two main classes. Such models posit an initial autonomous processing phase, followed by interactive processing. This results in the claim that the processes of lexical access and selection are autonomous, providing a set of possible candidates for assessment against the constraints emanating from higher-order representations. Here, then, the functionality of the selection process is less constrained, and the definitional boundary between selection and integration becomes unclear (an issue I will return to further on).

The functional architectures within which these various kinds of models are implemented show a quite wide range of possibilities. Autonomous models are typically conceived of as static systems with a collection of separate informational lists (e.g., an orthographic list, a phonemic list). Search procedures operate on these lists on the basis of some computed input representation, resulting in a discrete output, such as an abstract orthographic code for a visually presented word (e.g., Forster's (1979) serial search model). Interactive models are seen as dynamic systems, with a continuous flux in the activational state of the presumed processing units (such as line segments, or wickelphones). The processing units are structured either as unitarian one-detector-one-unit ensembles (e.g., Morton's (1969, 1979) Logogen model), or along the lines of parallel networks (e.g., McClelland & Rumelhart's (1981) interactive-activation model), and more recently as local or distributed representations in connectionist networks (e.g., McClelland & Elman's (1986) Trace model). Hybrid models for the most part lean towards activational implementations (e.g., Marslen-Wilson's (1987) Cohort model, the checking model by Norris (1986), and Forster's (1989) modified search model).

Given this proliferation of models, it makes little sense to set up a research programme to verify or to invalidate the constellation of representational and processing assumptions of any one particular model. A more fruitful approach, I believe, is to move away from the implementational details of specific models, to focus instead on general properties, and to thereby try and constrain the problem space within which the word-recognition process is to be situated. From this more removed perspective, it is clear that a major division among theories of lexical processing concerns the debate whether or not the effects of context should be given a post-selectional locus within an information-processing account of word recognition. As a first approximation, what is meant by 'context effects' here, are the semantically-based effects of sentential information which cannot be directly assigned to the specific meanings of the individual words in the sentence. Such semantic information is often referred to as higher-order information, reflecting the fact that it is assumed that this information as such is not represented at the level of the mental lexicon. The locus of the effects of higher-order information during spoken-word recognition forms the main experimental question for the research programme to be presented here. A further question that will be addressed focusses on the processing effects of a less global source of information, namely semantical aspects of verb-contexts, such as the selectional constraints arising from the (in)animacy of verbs. This kind of information provides a possibility to test between two classes of autonomous processing models which differ in their claims concerning what kinds of lexically represented information can affect the word-recognition process. To the extent that clear lexical- and sentential-semantic context effects are found and can be located within the framework of the three functional information-processing levels outlined above, this will contribute to a general explanatory account of on-line lexical processing, and will, therefore, provide evidence in favour of a broad class of models, as opposed to some particular mutant.

In the following section I will discuss some of the psycholinguistic literature on context effects and lexical processing.

Semantic-context effects during on-line lexical processing

Two issues are of central importance when speaking about semantic-context effects and lexical processing. One concerns the kind of semantic information involved, the other concerns the locus of the effects of this information. With respect to the latter, the issue is more appropriately phrased in terms of the basic functional framework described earlier, delineating access, selection, and integration processes. As was pointed out above, a major separation between competing accounts of the word-recognition process concerns which sources of information are thought to influence lexical selection. The autonomists hold that only information up to the level of the mental lexicon can affect lexical selection, whereas the interactionists claim that, for instance, world knowledge can also influence the selection of the appropriate word.[1]

With respect to the nature of semantic-context information, a distinction should be made between lexical- and sentential-semantic information. There are no hard and fast definitions here, in part because we lack a well-defined theory of the semantics of natural languages. However, as the terms suggest, the main difference is whether the information is thought to be represented at the level of the mental lexicon. Lexical-semantic context effects derive from meaning representations within the mental lexicon, whereas sentential-semantic context effects implicate extra-lexical meaning representations. The distinction is important because of its consequences for the debate on the locus of context effects. Lexical-semantic context effects such as the classical associative word priming effects (Meyer & Schvaneveldt, 1971) can be explained by processing mechanisms within the lexical level, without having to appeal to effects from higher-order meaning representations. Lexical effects, therefore, are of little consequence for deciding between autonomous and interactive word-recognition models. However, it is the case that lexical-semantic effects can in principle separate two classes of autonomy models which differ in their assumptions concerning the content of the lexical processing domain. Some autonomy models (e.g., Forster, 1976) assume that lexical access and selection operate within a domain which is restricted to basically only form representations. Other autonomy models (cf. Seidenberg, 1985) also include lexical-semantic information within this processing domain. If effects of such information are obtained, and if, moreover, these effects can be located within access and/or selection processes, then this would provide clear evidence in favour of the latter as opposed the former kind of autonomy model. To investigate this issue, some of the experiments reported here manipulated the influence of lexical-semantic information during on-line word recognition, by using differently constraining verb-contexts. This manipulation will be described in more detail in Chapter 3. To continue the present discussion, I turn to a consideration of sentential-semantic information.

Unlike lexical effects, sentential-semantic context effects derive from higher-order meaning representations. Locating these effects can separate autonomous and interactive processing models. Because lexical-semantic priming effects cannot settle the debate between autonomists and interactionists, I will not discuss the by now vast literature on priming (see Neely (1990) for a selected review of priming effects in visual-word recognition), but will instead concentrate on research on sentential-semantic context effects on lexical processing. I do not propose to present an exhaustive compilation of this research. My approach is highly instrumental: I will discuss a number of investigations which I believe to be pertinent to the issues raised in this dissertation, directing the searchlight in particular on those studies which have explicitly attempted to localize the effects of sentential-semantic information within the recognition process. Moreover, the discussion will be biased towards research in the auditory modality.

Before embarking on this brief review, it is necessary to consider what kind of results provide evidence that enables pinpointing the locus of sentential-semantic context effects. More specifically, on the basis of what kind of data can it be validly claimed that the lexical selection process is or is not affected by sentential-semantic information? The first obvious criterion is that the data should reflect on-line processes as directly as possible. That is, the observed response should be closely linked in time to the presumed processing operations, which effectively rules out all data gathered with so-called off-line tasks, such as meaningfulness judgements, cued recall, and the like. What this implies for the present question is that the data should be a reflection of the ongoing processing events elicited by the particular spoken word under investigation, as a function of the experimental manipulations, i.e. semantic-context variations. This necessitates reaction-time data that are gathered via on-line tasks which are performed by listeners during or immediately following the processing of the target word. A second criterion is that the data should be a manifestation - at least in part - of computations that occur during the lexical selection process. This is a crucial criterion, and one of the more difficult ones to meet. A major reason for this difficulty is the fact that when talking about on-line context effects, one is inevitably also talking about experimental paradigms, on-line reaction-time tasks, and their respective effects. Much of the psycholinguistic literature on lexical processing can be read as an extended attempt to rid real-time performance of the contamination brought about by the invasive technique used to observe that performance. Unfortunately, there is as yet no sufficiently calibrated ecologically valid on-line measure available.[2] This can be readily seen in the literature concerning the locus of sentential-semantic context effects during lexical processing. The claims being made lean heavily on the presumed characteristics of the particular configuration of paradigm and on-line task used, and much of the discussion serves the purpose of explaining away potential artifacts due to task effects. A final criterion, then, is that variations at the level of the data should as far as is possible be elicited by task-independent manipulations.

Zwitserlood (1989a) provides a critical survey of the most prevalent paradigms and tasks in spoken-word recognition research, together with some of the main effects found in this research. She focusses on the extent to which effects can be taken to reflect lexical selection processes, and evaluates techniques using speech and noise (cf. Samuel, 1981; Samuel & Ressler, 1986; Warren, 1970), speech continua (cf. Connine, 1987), shadowing (cf. Marslen-Wilson, 1985), word monitoring (cf. Marslen-Wilson & Tyler, 1980), mispronunciation detection (cf. Cole & Jakimik, 1978), and phoneme monitoring (cf. Cutler & Norris, 1979; Foss & Gernsbacher, 1983; Foss & Ross, 1983). She concludes, and I agree, that all of these experimental procedures are in some way flawed with respect to their ability to securely relate the data to the operations of the lexical selection process. One problem is that many of the techniques gather the timed response at non-lexical levels, such as phonemes or semantic categories. This opens the door for pre-lexical or post-selectional interpretations of obtained effects (cf. Cutler & Norris, 1979; Eimas, Marcovitz Hornstein, & Payton, 1990). A second problem is that the elicited responses often have insufficient temporal resolution to separate lexical selection from lexical integration processes. The root of this problem lies in the link between the on-line processing events related to the spoken word under investigation, and the moment in time at which an attempt is made to tap into the processing system by means of some experimental task. Ideally, the processing and response events should coincide. This ideal is best approximated in cross-modal paradigms, in which auditory stimulation is presented either simultaneously or in very close temporal succession with visual stimulation. The great advantage of this approach is that the amount of stimulus information that is available at the moment at which the subject is presented with a target stimulus - be it an auditory or a visual signal - can be manipulated with millisecond precision by the experimenter. This enables tapping into the ongoing process at basically any moment in time. Nevertheless, the power of cross-modal paradigms to provide insight into on-line processes is constrained by the kind of task used to obtain the reaction-time responses. As a rule, this is either lexical decision or naming. The relative merits of these tasks will be discussed in the following section. Here, I will mention some of the main results obtained with the cross-modal approach in the domain of lexical processing.

The cross-modal paradigm has been used extensively in research on the on-line resolution of lexical ambiguity (e.g., Blutner & Sommer, 1988; Burgess, Tanenhaus, & Seidenberg, 1989; Oden & Spira, 1983; Prather & Swinney, 1988; Swinney, 1979; Tanenhaus, Leiman, & Seidenberg, 1979). Subjects hear sentences containing words with multiple meanings, where the overall meaning of the preceding context biases for one particular meaning. Following the ambiguous word, subjects make a speeded response to a target word which is semantically related to one of the distinct senses of the ambiguity. A common finding is that immediately following presentation of the ambiguous word multiple senses are activated, whereas some 200 msec later only the appropriate word sense is available. Meaning dominance and lexical frequency exert some influence (cf. Lucas, 1987; Simpson & Burgess, 1985), but the basic pattern that has been obtained is multiple sense activation irrespective of contextual information, followed by context-sensitive single selection. This has been taken as strong evidence that lexical identification is an autonomous process.

A small number of cross-modal priming studies has provided evidence contrary to this view. Seidenberg, Tanenhaus, Leiman, and Bienkowski (1982) report an experiment in which they used noun-noun and noun-verb ambiguities in biasing and non-biasing contexts. In non-biasing contexts, both meanings of both kinds of ambiguities were accessed. This was also observed for noun-verb ambiguities in biasing contexts, but noun-noun ambiguities showed selective access for the appropriate contextual meaning. Although Seidenberg et al. assign the origin of this effect to intra-lexical priming (that is, spreading activation effects within the mental lexicon between semantically related words), thereby preserving the assumption of context-insensitivity, an alternative interpretation in terms of selective activation cannot be entirely excluded on the basis of their data. Tabossi, Columbo, and Job (1987) and Tabossi (1988a) report data which they claim are in support of selective activation effects of semantic context on the processing of ambiguous words with dominant and subordinate meanings. The words were embedded in sentences which biased either the dominant or the subordinate meaning by priming characteristic semantic features of these meanings (e.g., "The violent hurricane did not damage the ships which were in the *port*", "Deceived by the identical colour, the host took a bottle of barolo, instead of one of *port*"). The results show that both dominance and context affect the sense selection process. Multiple meanings are activated in the absence of strong sentential constraints, but "when contexts impose constraints on the dominant meaning of an ambiguous word, and both dominance and context converge on the same semantic information, the subordinate, contextually incongruent meaning of the ambiguous item need not be accessed" (Tabossi, 1988a, p.335; see also Simpson, 1981, 1984; Tabossi, 1988b). The authors argue that effects of sentential context on lexical processing depend critically on the sufficiency of the semantic constraints realized in the materials.

So, although the prevailing view in lexical ambiguity research is in favour of an initially context-insensitive lexical process, the issue is not yet decided. However, with respect to locating context effects within the lexical selection and integration processes, it is unclear whether the ambiguity research will at all provide a solution to the autonomist-interactionist debate. Lexical ambiguity resolution in sentential contexts is a process which involves the integration of word meanings within the higher-order meaning representation of the sentence. What this implies is that the functional separation into selection and integration processes does not really apply with respect to the process of disambiguation (cf. Tanenhaus & Lucas, 1987; Tanenhaus, Dell, & Carlson, 1987). That is, the research on the processing of lexically ambiguous words is not concerned with the identification of the ambiguous word itself from among alternate form entries in the lexicon. This aspect of selection among competing candidates is taken for granted. The empirical questions focus instead on the time-course and the cognitive penetrability of the sense selection process. So, although the lexical ambiguity data might show that lexical access is an autonomous process, they do not further constrain the locus of contextual effects.

There is relatively little cross-modal research on the effects of context on the on-line processing of unambiguous words. Whitney, McKay, Kellas, and Emerson (1985) report data that are in accordance with a context-insensitive model. They used a cross-modal semantic priming paradigm with a stroop task. Subjects heard sentences that biased high- or low-dominant properties of the sentence-final unambiguous noun (e.g., "The boy skinned his trout", "The boy dropped his trout"). Following the offset of the spoken noun, subjects saw a word related to either property (e.g., scales, slimy). The word was presented 0, 300, or 600 msec after the sentence, and was printed in coloured ink. The subjects' task was to name the colour. An interference effect was obtained relative to a control sentence (e.g., "The boy skinned his knee", "The boy dropped his milk") at the 0-msec delay for both visual targets, irrespective of the biasing context. This effect indicates that both meaning aspects of the noun had become activated, and that their activational level was not differentially modulated by the sentential-semantic information. At the 300- and 600-msec delays the high-dominant property still showed an interference effect for both biasing contexts, but the low-dominant property only produced an interference effect in the appropriately biasing context.

This study has been criticized by Tabossi (1988c). She argues that a subset of the sentences used by Whitney et al. provides insufficient semantic constraints to guide access to selected properties of a noun's meaning. This would imply that Whitney et al. failed to find selective contextual effects at the 0-msec delay because their sentences were, in general, too much like neutral sentences. To support her critique, Tabossi reports cross-modal semantic priming research using a lexical decision task for visually presented target words. Each target word was related to one meaning aspect of an unambiguous noun occurring at the end of a spoken sentence. The overall meaning of the sentence was either related to the meaning aspect of the noun denoted by the target, not related to any specific aspect of the noun's meaning, or related to some other distinct meaning aspect of the noun. Her results show that responses to the target words were significantly facilitated when the sentence was related to the meaning aspect of the noun denoted by the target, slower when the sentence was not specifically related to meaning aspects of the noun, and slowest when the sentence was related to a meaning of the noun that was not reflected by the visual target. Tabossi concludes that sentential context can immediately affect the interpretation of unambiguous nouns, "both facilitating access of those aspects of its meaning that are contextually relevant and interfering with the retrieval of other aspects of meaning" (Tabossi, 1988c, p.156). This conclusion can be criticized on the basis of the temporal sequencing of the unambiguous noun and its target. In particular the fact that the visual targets were always presented following the acoustic offset of the noun, weakens the validity of Tabossi's processing claims. I will return to this issue further on, when I consider the implications of the temporal properties of spoken language for the on-line comprehension process.

Although I am restricting the discussion here mainly to research in the auditory modality, some recent experiments on context effects on visual lexical processing should be mentioned. A number of reading researchers has reported context effects which evolve from semantic effects beyond intra-lexical priming, and they argue that these effects provide an important argument against the standard claim by autonomists that sentential-semantic context effects are in fact only a reflection of associations between individual words in the discourse (e.g., Forster, 1981). The research uses normal and scrambled sentences containing semantically related prime-target pairs in identical positional slots in both kinds of sentences. The sentences are presented word by word, using rapid serial visual presentation, self-paced reading, or quite slow fixed presentation durations (ranging from 300 to 800 msec per word). The standard task is word naming. If intra-lexical spreading activation is sufficient to account for contextual effects, then the claim is that equal priming should obtain with both kinds of sentences. If, however, information other than lexical-semantic information is operative (e.g., such as derives from the integrated meaning representation), then facilitation should be greater with normal than with scrambled sentences. This latter prediction is generally upheld (e.g., Masson, 1986; O'Seaghdha, 1989; Simpson, Casteel, Peterson, & Burgess, 1989). What this research shows then, is that a simple lexical activation account of context effects does not capture the full extent of these effects: a higher-order meaning representation is clearly implicated. This research is in line with a great deal of reading research on context effects on word recognition (e.g., Fischler & Bloom, 1979; Forster, 1981; Stanovich & West, 1979; West & Stanovich, 1982). The reason why I am mentioning it separately is that these experiments have carefully teased apart and tested lexical- versus sentential-context effects. However, contrary to what is claimed in this literature, these experiments by no means unequivocally pinpoint the locus of these extra-lexical effects, and, therefore, they do not provide a definitive argument against autonomy models.

In the first place, the use of scrambled sentences or word lists as the standard comparison for sentential-semantic effects in normal sentences, can be criticized on the grounds that the ongoing process might differ substantially between the two (cf. Duffy, Henderson, & Morris, 1989). In the second place, the visual signal of the words in the sentences and of the target word is complete and fully legible, and the target words are presented following the whole context sentence. This means that the ongoing process is assessed at a moment in time at which all of the information is at least physically available, and it is uncertain to what extent it has already been processed. This makes it very difficult to claim that the observed priming effects arise solely - or even in part - from operations of the lexical selection process. The interactive processing claim strongly relies on the assumption that reaction-times obtained immediately following the visual presentation of a critical target word will indeed reflect only those on-line processing events that are associated with the target word. An additional assumption is that naming latencies are a pure and uncontaminated measure of access and selection processes. In other words, the whole line of reasoning is massively task-dependent: the research has no independent grounds to motivate that the data reflect lexical selection processes.

In part, this critique can be extended to almost all research in the visual modality. The fact that visual word information is instantly and fully available is one of the major drawbacks in using written language to investigate the time-course of on-line lexical processing. In contrast, spoken language is stretched out over time, and it therefore provides the possibility to control the amount of physical information that has been received when the activational state of the processing system is assessed by means of some reaction-time technique. However, in the cross-modal research mentioned above on the processing of unambiguous nouns in variously constraining sentential contexts, the visual target word was always presented following the acoustic offset of the sentence-final noun. Given that many spoken words can be reliably identified prior to their offsets (cf. Marslen-Wilson, 1987), it cannot be excluded that the reported selective activation effects are the result of post-lexical integration processes which became operative well before the visual targets were presented. This issue brings us back to the question raised earlier on how to obtain reaction-time data which reflect the operations of the lexical selection process.

One approach here, which exploits to the full the temporal characteristics of spoken language, is to use a cross-modal paradigm with partial acoustic primes. Instead of presenting the subjects with fully pronounced prime words, the signal is cut off at various points before its offset, thereby exactly controlling the amount of sensory information that has been presented before the visual target word appears. The great advantage of partial primes is that they enable experimental manipulation of the constraining impact of the incoming signal on the lexical identification process (assuming appropriately validated functional operationalizations of prime length). What this implies with respect to investigating the cognitive penetrability of the lexical selection process, is that the experimenter can ensure at the moment in time at which a reaction-time response is obtained, that the signal as such is insufficiently informative to uniquely identify one single candidate in the lexicon. In other words, following an appropriately operationalized partial prime, the momentary state of the lexical processing system is characterized by multiple competing lexical entries, which is the single most important defining functional feature of lexical selection. Embedding such partial primes in differently constraining sentential contexts enables assessing the effects of these contexts on the lexical selection process.

To date the only well-documented study using partial primes is that of Zwitserlood (1989a, 1989b; see Marslen-Wilson (1984, 1987, 1989) for a brief mention of pilot and related work). She used a cross-modal semantic priming paradigm in combination with a lexical decision task on visually presented target words, and manipulated the length of the acoustic signal that was presented of the primes, using four different prime lengths. Zwitserlood related these various lengths to different stages of the word-recognition process - distinguishing between access, selection, and integration processes - and attempted to locate the effects of sentential-semantic information within one or more of these processes. Her results provide evidence that higher-order semantic information influences the lexical selection process. When a visual target was semantically related to a prime which was appropriate with respect to the preceding sentential context, the activational level of the target was increased (relative to a neutral control baseline) at a moment in time where the sensory information by itself was insufficiently constraining to distinguish between appropriate and inappropriate word candidates. Moreover, at the same point in time, the activational level of targets related to contextually inappropriate primes was decreased.

Zwitserlood's study demonstrates the power of the cross-modal partial priming approach for investigating on-line lexical processing. This power derives in part from the fact that her research meets the criteria described earlier for relating data to the lexical selection process. That is, cross-modal partial priming taps into the ongoing process in real-time, it elicits responses which are closely linked in time to the underlying comprehension process, and it entails a task-independent manipulation on the basis of which it can be claimed that computations of the lexical selection process are being picked up. For these reasons, Zwitserlood's results can be interpreted as support for the processing claims of interactive models of word recognition.

Given the success of the cross-modal partial priming paradigm to unravel at least some of the intricacies of the spoken-language comprehension process, the research programme to be reported in the chapters to follow embraces this paradigm as its main experimental tool. However, there are some important implementational differences with respect to Zwitserlood's work, and these need to be discussed and motivated first, before turning to the actual experiments.

Tapping on-line lexical processing: Cross-modal candidate priming

Although I believe that the cross-modal partial priming paradigm is a significant step forward, it cannot be proclaimed absolute ruler of the on-line processing kingdom. The history of experimental psycholinguistics is filled with attempts to find a royal route into the language system. To date, we do not have a well-defined technique available which gives us privileged access into the real-time mental events that we assume to be operative when people are in the process of understanding spoken language. This lack of a good diagnostic tool has led to a quite diverse collection of experimental paradigms and tasks, and one of the more important problems facing a researcher is to decide which combination of paradigm and task is most suited for the particular question under investigation. This dissertation uses a new paradigm, which I have called cross-modal candidate priming, in combination with a naming task, a standard reaction-time technique in psycholinguistics.

In cross-modal candidate priming as operationalized here, subjects are presented with a spoken sentence which ends in a prime word, followed by a visually presented target word. The subjects' task is to read the target word out loud as soon as it is presented. The prime word is either partially or fully pronounced (for example, subjects might hear the first 300 msec of the prime, or they might hear the whole prime). The relationship between the prime-target pair is such that the target is either identical to the prime, or closely identical in terms of its acoustic-phonetic form. Hence the term 'candidate' priming: depending on the constraints of the acoustic signal making up the prime, a number of words are possible candidates for identification. So, for example, subjects might hear a sentence ending with the partially produced prime 'squir', and see the word 'squirt' or 'squirm'. The rationale behind this paradigm is the same as underlies the traditional semantic priming paradigm (cf. Meyer, Schvaneveldt, & Ruddy, 1975; Neely, 1990). Activation of the prime word is presumed to carry over to those words that share aspects of the information represented at the level of the prime. The degree of activation depends on the extent of the informational overlap. By manipulating the length of the partial primes, the amount of sensory information is controlled that is available when the activational state of the lexical processing system is assessed. So, for instance, what is the state of the system immediately after the signal for 'squir' has been presented? And in what ways does this state change as a function of the sentential information in which the prime is embedded?

As was already discussed in the preceding section, cross-modal semantic priming has been used successfully in many psycholinguistic experiments, in particular in research on the resolution of lexical ambiguity in sentential contexts. This research demonstrates that clear activational effects can be obtained on the basis of auditory priming information followed by visually presented target words. Very little research, however, has been done with partially pronounced auditory primes, and, to my knowledge, no work has been published using partial primes in a cross-modal candidate priming paradigm. Zwitserlood's (1989a,b) work on cross-modal semantic priming with partial primes has shown that this is a viable paradigm to investigate on-line lexical processing, at least when used in combination with a lexical decision task. There are, however, two important differences between Zwitserlood's procedure and the one used in this dissertation research. Zwitserlood used semantic priming and lexical decision, whereas I use candidate priming and naming.

The motivation for using candidate priming is that I wanted to observe on-line lexical processing as directly as possible, within the limitations inherent to reaction-time measurement. A major factor here, as in all chronometric research, is the length of the inferential chain that lies between the observed data and the postulates of the underlying functional model. For the purposes of the present research, there is no reason to include assumptions concerning lexical-semantic networks and the spread of activation in such networks, as is the case with the semantic priming paradigm. Therefore, I opted for candidate priming, in which the words under investigation are themselves also the words on which the reaction-time data are gathered. The desire to strip the measurement procedure to its barest bones, is also the reason why I chose naming as the experimental task for all of the research to be reported here.

Measuring on-line lexical processing: The naming task

Basically, when using cross-modal paradigms with visual word targets, the choice of a reaction-time task is between naming and lexical decision. This is not an easy choice. In the past years, a vigorous debate has been going on as to which task is most suited for investigating on-line lexical processing. The main argument against using lexical decision is that the decision component of this task is susceptible to differences in the visual familiarity and the meaningfulness of the word targets. So, for instance, the fact that high-frequency words standardly lead to significantly faster lexical decision times than low-frequency words, could in part be due to the fact that because of their overall lower familiarity, low-frequency words tend to be more difficult to discriminate from non-words than is the case for high-frequency words. Therefore, so the argument goes, lexical decision results are contaminated by the post-identification influence of the discrimination difficulty, which implies that lexical decision latencies are inappropriate measures of lexical access and selection processes (cf. Balota, 1990; Balota & Chumbley, 1984, 1985; Balota & Lorch, 1986; Chumbley & Balota, 1984; McCann & Besner, 1987; McCann, Besner, & Davelaar, 1988). The main argument against using naming is that the phonological information required for the response could become available via a direct mapping from spelling to pronunciation, without any involvement of the mental lexicon, in particular without involvement of meaning representations (cf. McCusker, Hillinger, & Bias, 1981; McRae, Jared, & Seidenberg, 1990; Patterson & Coltheart, 1987; Seidenberg, 1989, 1990; Seidenberg & McClelland, 1989).

The proving ground for the debate has been the locus of the word-frequency effect in naming and lexical decision (cf. Balota & Chumbley, 1984; Frost, Katz, & Bentin, 1987; Paap, McDonald, Schvaneveldt, & Noel, 1987; Seidenberg, Waters, Barnes, & Tanenhaus, 1984; Taraban & McClelland, 1987), and the scales of the evidential balance have swung between pre- and post-lexical loci (see Monsell, Doyle, & Haggard (1989) for a summary and discussion of this research programme). At present, no evidence has emerged which emphatically favours one task over the other, and it is perhaps unrealistic to assume that the scales will eventually settle in a stable equilibrium. So, once again, the researcher has to opt for a task in the light of the particular questions being addressed. The following considerations led me to favour naming over lexical decision.

The first has an historical flavour. Like all research, my dissertation is in part a product of the state of affairs in the field at the time at which it was conceived. The Balota and Chumbley (1984, 1985) results had just emerged in the literature when the experimental programme reported here was defined, and the thrust of the evidence was in the direction of naming as opposed to lexical decision, at least if one was interested in investigating on-line lexical access and selection processes. The fact that naming, but not lexical decision, seems relatively unaffected by the familiarity and meaningfulness of the target words, provides an important reason to select naming over lexical decision. Events since then have somewhat modified this picture, indicating that lexical decision might not be as flawed as has been claimed (cf. Monsell et al., 1989; Paap et al., 1987), but the issue of post-lexical discrimination effects in lexical decision as opposed to naming remains a factor when choosing between the two tasks (cf. Balota & Chumbley, 1990; McCann & Besner, 1987; McCann et al., 1988).

A second consideration concerns the nature of the tasks themselves. Lexical decision requires a binary classification response, and involves discriminating between words and nonwords. Both aspects are far removed from normal language use. This makes lexical decision particularly susceptible to response strategies (cf. Besner & Johnston, 1989; Neely, Keefe, & Ross, 1989; Seidenberg, 1989; Stanovich & West, 1983). Naming on the other hand, is a natural and well-learned response. I do not want to belabour the ecological validity of naming over lexical decision - in either task the experimental situation remains unnatural - but it certainly is the case that naming belongs to the standard repertoire of all literate language users, whereas lexical decision does not.

A third consideration derives from the backward priming effect (cf. Kiger & Glass, 1983). Backward priming refers to the facilitatory effect of a target word presented after a prime, on the processing of that prime. This facilitatory effect in turn affects the reaction-time to the target. This effect potentially poses problems for the interpretation of results from lexical ambiguity studies purporting to demonstrate multiple access of meanings (cf. Glucksberg, Kreuz, & Rho, 1986), but also more in general for studies of context effects on-line lexical processing. Although the initial dismay at this finding has diminished in the light of research indicating that at least multiple meaning access is not an artifact of backward priming (cf. Burgess, Tanenhaus, & Seidenberg, 1989; Jones, 1989; Peterson & Simpson, 1989; Tanenhaus, Burgess, & Seidenberg, 1988; but see Van Petten & Kutas, 1987), it remains a possible source of interpretative noise. In this respect it is important to note that research by Seidenberg et al. (1984) provides evidence that backward priming does not occur when the naming task is used. This is in part supported by work reported by Peterson and Simpson (1989). Although these authors did observe some backward priming effects in the naming task when single-word primes were used, these effects disappeared when the target words were preceded by sentence primes.

A final consideration involves the issue of contact with lexical representations in the mental lexicon. This does not concern an argument against lexical decision, but a potential problem for the naming task. As was noted above, it has been claimed that naming need not involve accessing the mental lexicon (cf. Patterson & Coltheart, 1987; Seidenberg, 1990; Seidenberg & McClelland, 1989). For languages with alphabetic or syllabic scripts, naming could, so the argument goes, be performed by assembling the required pronunciation on the basis of knowledge of grapheme-phoneme correspondences. This route bypasses the mental lexicon, thereby rendering the naming task inappropriate as an investigatory tool for contextual effects during on-line lexical processing. The validity of the so-called dual-route theory of reading is the subject of much controversy (see Humphreys & Evett (1985) for an appraisal, with commentary). Considerable effort has been spent in attempting to demonstrate non-lexical routes for pronunciation, focussing on orthographic regularity effects, and on the pronunciation of nonwords (cf. Carr & Pollatsek, 1985; Glushko, 1979; Humphreys & Evett, 1985; McCann & Besner, 1987). The upshot of these efforts is that a non-lexical pronunciation route cannot be ruled out in all stimulus situations, but it is by no means the case that naming basically does not involve the lexicon. Even in so-called 'shallow' orthographies (that is, orthographies in which the spelling-sound correspondences are quite regular, like Dutch - the language used in the present research - or Serbo-Croatian), it is clear that lexical effects emerge in naming latencies (e.g., Carello, Lukatela, & Turvey, 1988; Hudson & Bergman, 1985).[3] Most persuasive among such lexical influences are semantic priming effects. There are numerous studies demonstrating that semantic and associative priming effects do obtain in naming (e.g., Balota & Lorch, 1986; Becker & Killion, 1977; Carello et al., 1988; Colombo & Williams, 1990; de Groot, 1985; Flores d'Arcais & Schreuder, 1987; Flores d'Arcais, Schreuder, & Glazenborg, 1985; Forster, 1981; La Heij, 1988; La Heij, v.d. Heijden, & Schreuder, 1985; Lupker, 1985; Meyer et al., 1975; Schustack, Ehrlich, & Rayner, 1987; Seidenberg et al., 1984; Warren, 1977; West & Stanovich, 1982). Finding different naming times for target words as a function of the semantic relationship with a preceding prime, demonstrates that in such stimulus situations lexical meaning representations have been accessed during the process from print to pronunciation. Of course, this does not provide an absolute guarantee that in the current experimental approach, semantic-context effects will emerge in naming latencies. Within a lexical route to naming, it remains possible to pronounce a word via a link between orthographic and phonological form representations, without involvement of lexical-semantic information. Although the literature indicates that meaning representations can play a role during pronunciation, it is an empirical issue whether the combination of cross-modal candidate priming with naming will reflect semantic-context effects.

In summary, I have chosen naming over lexical decision as the experimental task for the present research programme because (1) it avoids the problems associated with the binary decision component of the lexical decision task, (2) it is a natural language task, (3) it is less plagued by the backward priming effect than lexical decision, and (4) it has proven to be sufficiently sensitive to pick up on effects of semantic context at the level of lexical meaning representations. In using naming in combination with the cross-modal candidate priming paradigm, I am attempting to approach the on-line lexical analysis process as closely as is possible with reaction-time methodology.

A brief on the remainder

Three more chapters follow. In Chapter 2 the procedure for the selection and validation of the basic set of prime-target words is described, and a reaction-time experiment is reported which demonstrates that cross-modal candidate priming is a viable paradigm to address issues in on-line spoken-word processing. Chapter 3 contains the main experimental programme on context effects. The chapter begins with a section on the sentential material used for the experiments, and continues with an extended discussion of the differing predictions made by various autonomous and interactive processing models. Five reaction-time experiments are then reported. The first experiment does not provide evidence in support of contextual effects during lexical selection. Moreover, this experiment fails to pick up on any semantical effects, even following full presentation of the spoken word. The remaining four experiments can be seen as an extended attempt to explain these results. This attempt is characterized by a somewhat depressing succession of null-effects. Chapter 4 discusses some reasons why these null-effects may have obtained.

2 AUDITORY LEXICAL PROCESSING IN NEUTRAL CONTEXTS

This chapter contains the empirical foundations for the main research programme on context effects. First, the procedure for selecting the word stimuli is described. This entailed a computerized search through a lexical database to obtain a basic set of stimuli. This set was subsequently tested in a gating study, which served, among other things, to operationalize the various signal lengths of the partial primes to be used in the reaction-time research. Following the stimulus selection section, a reaction-time experiment is reported which uses the cross-modal candidate priming paradigm with naming. The chapter concludes with a discussion of the validity of this particular experimental configuration to investigate on-line lexical processing.

Selecting the word stimuli

The first step in selecting the word stimuli was a computerized search through a phonetically coded Dutch corpus containing 72.135 entries. This corpus contains transcriptions of the preferred spellings of all lemmata in the "Woordenlijst van de Nederlandse Taal" (1954), expanded with lemmata from Appendix B1 of the Uit den Boogaart (1975) word-frequency listing. A search algorithm was written that produced phonetically ordered sequences of words with maximally overlapping forms, considered from word onset. So, for example, given the entry /beurt/, the algorithm searched for all other entries in the corpus beginning with the sequence /beur/. These entries were then examined for the presence of wordpairs. That is, two words whose phonetic forms separate at or close before their offset. One such wordpair is /beurt/-/beurs/. In addition to their phonetic overlap, wordpairs were selected on the basis of the following criteria:

1. The number of additional words that match the phonetically overlapping form of the words making up a wordpair had to be small, and their frequency counts had to be closely matched. Moreover, the number of additional words had to be relatively constant between the selected wordpairs. The main reason for this combined criterion is that there is some evidence that the absolute number of words that are similar in their form to the word being processed, as well as the frequency distribution of these alternative words, affects the processing of the stimulus word

(the so-called neighbourhood density and neighbourhood frequency effects, otherwise known as the competitor effect, cf. Coltheart, Davelaar, Jonasson, & Besner (1977), Goldinger, Luce, & Pisoni (1989), Grainger, O'Regan, Jacobs, & Segui (1989), Grainger & Segui (1990), Luce (1986), Luce, Pisoni, & Goldinger (1988), Marslen-Wilson (1990), Treisman, (1978)). Therefore, it seemed important to control for such possible effects.

2. The words making up a wordpair had to be closely matched on word frequency (frequency norms were as far as possible obtained from the Uit den Boogaart (1975) corpus, which contains some 720.000 tokens; not all of the selected words are represented in this corpus). This was done to avoid contamination of any obtained effects by processing effects due to differing absolute frequencies. In addition, all of the words had to have relatively low frequency counts (below 35 in the Uit den Boogaart corpus). This criterion was used to control for differential neighbourhood frequency effects. The research cited above indicates that in particular words with high frequency neighbours, but also high frequency words with low frequency neighbours (cf. Segui & Grainger, 1990), show interference processing effects. These effects do not obtain with low frequency stimulus words with low frequency competitors. Therefore, to be certain that the two members of a wordpair do not produce differential neighbourhood frequency effects, only low frequency pairs were selected.

3. Both words had to be either nouns, verbs, or adjectives, and had to have, preferably, the same form-class. This was done with an eye towards the planned research on the effects of sentential context on word processing; words from different form-classes often cannot be inserted in the exact same sentential contexts.

4. Both words had to be morphologically simple. So, for example, no prefixed, suffixed, or compound words were allowed.

5. Preferably, all words had to start with either a plosive or a fricative. This was done in part to facilitate the splicing of the same acoustic tokens into different sentential contexts; an important manipulation in the research reported further on in this thesis. Another reason was that there is some evidence that certain phonemic realizations in connected speech, in particular nasals, are quite strongly cued by coarticulatory information in their preceding signal, whereas others, in particular stops and fricatives, are much less strongly cued (cf. Fowler, 1984; Warren & Marslen-Wilson, 1987). It was decided to use those initial sound sequences which seem to affect their preceding signal as little as possible.

This combination of criteria resulted in a set of 91 wordpairs. In the second step of the stimulus selection process, these wordpairs were investigated in a gating study.

The gating study

In the gating study, each member of a wordpair was segmented from word onset into successive fragments of increasing duration. These fragments were presented to subjects, who were required to respond with the word they thought they were hearing. More details concerning the specific method and design will be given below. There are two main reasons for performing the gating study.

One reason is the necessity to verify that the phonetic similarity of the members of each wordpair as defined by the transcription in the corpus, has a counterpart in the perception of these words by adult listeners. So, given some initial stretch of speech which is neutral on the basis of the phonetic code as to which of the two words comprising a wordpair is being presented, is it indeed the case that listeners respond, on average, equally with either of the two words? In addition to providing a validation of the phonetic similarity of the members of each wordpair, the gating results will also provide information as to whether the two members are indeed adequately matched on their lexical characteristics (e.g., word-frequency, saliency, stress).

The second reason is that a profile is required of the words that are considered as possible candidates by listeners, as a function of the accumulating acoustic input. So, given some part of the initial acoustic signal of a word, what different words are deemed compatible with this signal by the listener? Such a profile provides a first approach to investigating an important aspect of the basic notion of lexical processing. Namely, the waxing and waning of the activational level of entries in the mental lexicon on the basis of incoming stimulus information.

Stimulus preparation

All words were spoken by a female native speaker of Dutch, who was naive with respect to the purposes of the planned research. Each word occurred at the end of a neutral carrier phrase, such as "Je gaat nu luisteren naar het woord ..." ('You are now going to listen to the word ...'). The reason for using a carrier phrase, as opposed to producing the words in isolation, was that eventually the same acoustic tokens were to be used as target words in experiments with meaningful sentential contexts. To ensure that after insertion of these words in experimental sentential contexts they will sound as natural as possible, it is best that the original recordings of target words also occur in sentences, thereby taking into account as much as possible the basic rhythmic and prosodic characteristics of connected speech. In addition, previous research on gating (in particular Zwitserlood's (1989a) work, but see also Grosjean, 1980; Salasoo & Pisoni, 1985; Tyler, 1984) has shown that response profiles to words presented in isolation are often characterized by a high percentage of missing responses and incorrect initial phoneme identifications. This emphasizes the importance of presenting words in a natural speech environment. The two words comprising a wordpair were each spoken at the end of the same carrier phrase and in immediate succession, so as to maximalize the similarity of the specific acoustic tokens.

The stimuli were recorded in one session in a sound-attenuated booth via a Revox B77 MK II taperecorder with a Sennheiser MD-421-N microphone onto an AGFA PER-368 audiotape. Subsequently the stimuli were digitized using a sampling frequency of 20kHz, with a band-pass filter range of 50Hz to 10 kHz, and stored on the magnetic disk of a VAX 750 computer.

The segmentation of the stimuli was done in the Speech Laboratory of the Max Planck Institute for Psycholinguistics. Using a waveform editor, the onset of the test words was located and digitally marked. From this mark onwards the word was divided into segments of increasing length. The first segment consisted of the first 40 msec of the word, the second of the first 80 msec, and so on until the final segment which contained the entire signal of the word. Each succession of segments making up a word was then recorded onto audiotape using a 12-bit D/A converter. The first segment of each word was recorded together with its preceding carrier phrase. Recordings of the subsequent segments of a word were not preceded by the carrier phrase, but followed the first segment with intervals of eight seconds of silence.

Design

The gating study consisted of two experimental versions. In each version only one member of the same wordpair occurred. The sequence of words in the two versions was identical, so that the two members of a wordpair occurred in the same position in each experimental list. Given that the total duration of an experimental version was over 3 3/4 hours long, it was decided to split each version into three contiguous sequences. This enabled test sessions of on average 75 minutes in duration, which is about the limit in a gating study before the subjects' performance deteriorates due to fatigue. Three breaks of 5 minutes were given during each session. The first sequence of both experimental versions was preceded by a practice list of three words, the other sequences were preceded by a practice list of two words.

Subjects
A total of 24 subjects was tested, 12 on each version. Subjects were recruited from the Max Planck Institute for Psycholinguistics student-subject pool, and were paid Hfl 35,= for their participation.

Procedure
Subjects were tested in groups of four on three successive days, one session of a sequence per day. Each subject sat in a carrel that provided a visual shield from the other subjects. The stimuli were presented via a Revox B77 MK II taperecorder. Subjects listened to the material over closed-ear Sennheiser HD-224 headphones. They were instructed to listen carefully to the input, and to respond after each auditory presentation with the word they thought they were hearing at the end of the carrier phrase. In addition, they were asked to indicate following each word response how confident they were that their response was indeed correct. The confidence ratings could vary along a 9-point scale, with scale value 1 representing a total guess, and value 9 full confidence in the correctness of the response. It was emphasized to the subjects that they were not to reflect at length about which word might match the input, but that they had to respond immediately with the first word that came to mind given the input.

Subjects recorded their responses via TANDY 200 micro-computers. They first typed in their word response and then a number from 1 to 9 for their confidence rating. Each response stayed on the screen of the micro-computer until all of the gates comprising a specific word had been presented. Following the response to the last gate (i.e., the whole word), the screen was wiped clear in preparation for the presentation of the next word. The onset of each new sequence of gates comprising a word was additionally signalled to the subjects by means of a 1-second 1kHz tone. Following this tone the carrier phrase was presented in combination with the first 40-msec segment of the appropriate word. Subjects then had eight seconds in which to give their word response and their confidence rating. Following these eight seconds, the next segment of the word was presented, without its carrier phrase and without a preceding warning signal.

Analysis of the gating responses
The main product of the gating study is a database of words which are considered by listeners to be compatible with a given input, and in which the relative compatibility is indicated by confidence ratings. The database was analyzed for the following information:

1. What words are considered viable candidates, and when?

2. What is the 'lifespan' of candidates across gates?

A main source of information contained in the gating responses concerns the words that are acoustically realized. I will call these words *Actual Words*. With respect to the Actual Words, the gating responses indicate which stretches of the signal are sufficient to activate the specific entry in the mental lexicon, and which stretches allow for subsequent unique identification.

Analysis of the response profile as a function of the succession of gates increasing in length from word onset through to word offset, provides an approximate picture of which words are potential candidates for recognition, at what moments in time. Additionally, the profile gives information on the correspondence of the perceptual data with the pre-gating defined phonetic similarity which provided the basis for selecting the 91 wordpairs. For the purposes of the research reported in this dissertation, the gating responses for the individual members of each wordpair were examined for the following response profile:

1. At some early point in the signal, both members of a wordpair had to occur as a response by 25-35% of the subjects, the responses had to be evenly distributed across the two members, and the confidence rating of the responses had to be below 4, on average. The remaining approximate 35% of responses had to be distributed across several words (i.e., no bias was allowed for a specific word). This point defines what I will call the *First bias position*.

2. At some later point in the signal - where 'later' is defined as minimally 80 msec - 65-75% of the subjects had to respond with the Actual Word, and the remaining subjects had to respond with the other member of the wordpair, which from now on will be referred to as the *Gating Competitor*. This later point defines the *Actual Word bias position*.

3. At a still further point in the signal, all of the subjects had to respond with the word being presented, and they had to continue giving this response for the remainder of the signal.

What this profile establishes is an operationalization of the two partial priming conditions to be used in the reaction-time research. The idea is that the signal making up the First bias position will result in the activation of multiple entries in the mental lexicon, among which at least the Actual Word and its Gating Competitor. At the Actual Word bias position, the signal should be supporting the Actual Word as the most viable candidate for identification, while at the same time not entirely excluding the Gating Competitor as a possible candidate. Taken together, the two positions are intended to reflect to some extent different aspects of the temporal dynamics of lexical processing, namely multiple activation followed by single selection.[1]

Results from the gating analysis
A clear pattern in the gating responses is that for the majority of the wordpairs the similarity of the two members - as defined in the corpus and to some extent by the five criteria listed above - is not upheld in their perception as reflected in this gating study. That is, one member of a wordpair shows the response profile as laid down in points 1-3 above, whereas the other member does not. In particular, it is often the case that the bias for the word that is being acoustically realized emerges quite abruptly, so that competing words are no longer considered viable candidates, thereby violating point 2 of the required response profile. Of the 91 wordpairs, only 9 show a fully symmetrical response pattern between their members. What this implies is that the phonetic code as used in the corpus is insufficiently detailed to capture all of the sound distinctions between the actual acoustic realizations of the members of a wordpair. Presumably, subtle coarticulatory differences which are not represented in the phonetic transcription, are being picked up by the listeners as cues for distinguishing between competing word candidates (cf. Howell, 1983; Warren & Marslen-Wilson, 1987, 1988). However, for the reaction-time research to be reported in this thesis a symmetrical response profile is not required. It suffices if one member of a wordpair elicits the desired pattern of responses. This word can be used as the input - the Actual Word - in the research on stimulus processing and lexical activation. The only advantage symmetrical wordpairs have to offer here is a replication factor. This of itself is desirable, but not crucial. Given the quite strict criteria described above for selecting the stimuli, the eventually resulting set of words can be considered to be homogeneous, and as such it establishes a major and sufficient replication dimension.

A total of 24 wordpairs have one member that meets the three defining points of the required response profile. The mean length of the signal that forms the First bias position is 227 msec (sd 74 msec). The mean length for the Actual Word bias position is 317 msec (sd 79 msec). The mean overall length of the 24 Actual Words is 604 msec (sd 78 msec). Table 1 lists the mean number of subjects (from a total of 12) responding with either an Actual Word or a Competitor at the First and Actual Word bias positions, together with the mean confidence ratings (ranging from 1 to 9) at these positions.

Table 1: Gating data for 24 Actual Words and their Gating Competitors.

	First bias position	
	Subjects ($\bar{x}$)	Conf. rating ($\bar{x}$)
Actual Word	4.2 (sd 1.3)	3.8 (sd 1.4)
Competitor	4.1 (sd 1.1)	3.9 (sd 1.7)
	Actual Word bias position	
	Subjects ($\bar{x}$)	Conf. rating ($\bar{x}$)
Actual Word	7.5 (sd 1.2)	5.9 (sd 1.4)
Competitor	2.5 (sd 0.8)	5.4 (sd 1.7)

The numbers in Table 1 show that at the First bias position the acoustic signal given as input to the subjects is insufficiently constraining to allow them to distinguish between the Actual Word and its Gating Competitor. At the same time, the signal does already significantly reduce the size of the lexical set that is compatible with the input: some 66% of the subjects opt for either the Actual Word or the Gating Competitor. At the Actual Word bias position, most subjects clearly prefer the word that is being acoustically realized as the candidate for identification. However, the signal is not as yet fully constraining: some 20% of the subjects still give the Gating Competitor as their response.

In addition to the gating analysis based on the three criteria described above, a second selection was performed. The main reason for this further analysis of the gating database was to enable an assessment, in the reaction-time research, of the extent to which the gating responses are in fact an adequate reflection of the words being considered by the subjects as possible candidates for identification. It is clear that the set of word responses produced in the gating study is an incomplete representation of the words which are phonetically compatible with the input, and which, by hypothesis, become activated in the mental lexicon as a function of processing the acoustic signal. In particular, this is the case for responses to the early gates, given that the gating procedure used here requires the subjects to respond with only one word following each presented gate. This requirement obviously does not preclude other entries in the mental lexicon from being appropriate candidates for identification. Therefore, a further 24 Actual Words were selected, to complement the set of 24 Actual Words and their Gating Competitors.

The 24 additional words have the gating response profile for Actual Words as described above with respect to the number of subjects responding at early and at late gates, but, in contrast to the previous set, they do not have a clear competitor. That is, these Actual Words are produced at early gates by 25-35% of the subjects, with a low confidence rating, and subsequently (a minimum of two gates along) by at least 65% of the subjects, but their acoustic signal does not specifically elicit any single Gating Competitor. The response profile of these 24 Actual Words is characterized by an emerging preference for the word being presented, in combination with a decreasing group of alternative responses, none of which is produced by a large number of subjects, or which is sustained as a response over long stretches of the signal. For these Actual Words, competitors were chosen from the corpus used to select the initial set of wordpairs. These competitors were not produced as responses in the gating study, but they are phonetically compatible with the initial signal of the Actual Word. The extent of the phonetic compatibility is the same as used to select the basic 91 wordpairs for the gating study. That is, maximal phonetic overlap of a competitor is defined as an identical transcription of the competitor and the Actual Word, up to the final phoneme of the Actual Word. These competitors will be referred to as *Dictionary Competitors*, to distinguish them from the Gating Competitors. Table 2 lists the mean number of subjects (from a total of 12) responding with an Actual Word at the First and Actual Word bias positions, together with the mean confidence ratings (ranging from 1 to 9) at these positions.

Table 2: Gating data for 24 Actual Words (paired with Dictionary Competitors).

	First bias position	
	Subjects ($\bar{x}$)	Conf. rating ($\bar{x}$)
Actual Word	3.2 (sd 1.0)	3.8 (sd 1.2)
	Actual Word bias position	
	Subjects ($\bar{x}$)	Conf. rating ($\bar{x}$)
Actual Word	8.4 (sd 1.2)	6.0 (sd 1.4)

The mean length of the signal at the First bias position is 217 msec (sd=68 msec). The mean length for the Actual Word bias position is 303 msec (sd=66 msec). The mean overall length of the 24 Actual Words is 572 msec (sd=74 msec).

The numbers in Table 2 closely match those for the first set of Actual Words, reported in Table 1. This match shows that it is possible to use the same basic criteria for selecting both sets of Actual Words, and that, therefore, in this respect a homogeneous set of stimuli has been established. The 48 Actual Words and their competitors serve as the basic stimulus pool for the reaction-time research reported in this thesis. They are listed in Appendix 1.

Why were the Dictionary Competitors not produced as responses during the gating study, despite their apparent phonetic similarity with the Actual Words being presented? Three reasons can be suggested. One reason might be that the lexical characteristics of the Dictionary Competitors are in some important respect different from those of the Gating Competitors. This, however, is not the case. The Dictionary and Gating Competitors are matched on grammatical class and number of syllables, and have corresponding word-frequency counts and distributions (Dictionary Competitors: mean frequency = 20, sd=25; Gating Competitors: mean frequency = 24, sd=19). Similarly, the set of Actual Words linked with Dictionary Competitors does not differ in terms of its lexical characteristics from the set linked with Gating Competitors (Actual Words with Dictionary Competitors: mean frequency = 18, sd=18; Actual Words with Gating Competitors: mean frequency = 17, sd=16). The density of the lexical space associated with the two sets of Actual Words also does not seem to be a contributory factor. The number of alternative responses produced at the First bias position for Actual Words linked with Dictionary Competitors is 4.6 (sd=1.9). For Actual Words linked with Gating Competitors the number is 2.6 (sd=1.7). At the Actual Word bias position, the number of alternative responses next to Actual Words and Dictionary Competitors is 2.4 (sd=1.0). For Actual Words and Gating Competitors the number is 1.4 (sd=1.3). There might be a tendency for the Actual Words linked with Dictionary Competitors to be somewhat more ambiguous, in the sense that they afford more alternative responses than the Actual Words in the other set, but the difference is not large. Clearly, given the overall pattern of lexical statistics for the Actual Words and the Dictionary and Gating Competitors, there is no basis for a lexical account of the absence of Dictionary Competitor responses in the gating results.

A more compelling reason arises from the basic off-line nature of the gating paradigm. Subjects in a gating study have time to reflect on the input, to evaluate a number of possible responses against the requirements of the instruction, and to select from within this response set the most appropriate word given the input. Under these circumstances, the subjects can profit maximally from all the various and subtle coarticulatory cues present in the acoustic signal. It could be the case, therefore, that the Gating Competitors are preferred over the Dictionary Competitors because of a marginally better fit between the form representations of the Gating Competitors and the accumulating input. Evidence that subjects can pick up and capitalize on minor coarticulatory differences in segmented stimuli, is provided by Warren and Marslen-Wilson (1987) in a gating study on acoustic cues in spoken-word recognition. Their subjects were attuned to anticipatory vowel coarticulation in word-final vowel-consonant transitions, between 20-msec time-windows. The first analysis of the present gating data has already shown that quite a few of the selected wordpairs are not judged to be as similar as their phonetic forms indicate. Presumably, coarticulatory information is a contributory factor here. The absence of Dictionary Competitor responses can be seen as another manifestation of this phenomenon.

The final reason is predicated upon the presence of coarticulatory information, and concerns the effective time-frame within which Dictionary Competitors can be expected to appear as responses. Despite the fact that the subjects hear all gates of each word, it is not the case that for the early segments of the signal all phonetically compatible words have an equal likelihood of being produced as a response. This is because of an often reported effect in the gating literature, which is that at early gates subjects most often respond with short, high-frequency words (cf. Grosjean, 1980, 1985; Salasoo & Pisoni, 1985; Tyler & Wessels, 1983; Zwitserlood, 1989;

but see Wayland, Wingfield, & Goodglass, 1989). Given that the overall frequency of the Dictionary and Gating Competitors is low, there will be a general tendency for them to emerge as responses at later moments in the signal. If coarticulatory cues serve to marginally differentiate between the two kinds of competitors, then with an increase in the length of the acoustic input, there will be an increase in the extent to which the subjects can make use of these cues to select among competing lexical alternatives.

A concluding caveat

A cautionary note has to be made with respect to the usefulness of gating data for language processing research. Their value should not be exaggerated. In particular, it is incorrect to claim that the response profiles elicited by means of the gating paradigm are true reflections of the on-line processes which occur during language comprehension. Zwitserlood (1989a) has conclusively demonstrated that gating is not an on-line task, despite claims to the contrary (Tyler & Wessels, 1985). She compared gating data with reaction-time data from an on-line cross-modal semantic priming paradigm, on the same set of spoken words within the same sentential contexts. Her data show that the gating paradigm overestimates the effects of sentential context on lexical processing, and, even more seriously, pinpoints the locus of these effects at a much earlier point in real-time information processing than the locus determined on the basis of the reaction-time results. This, however, does not imply that the gating paradigm is without merit for language research. Gating provides useful and otherwise unobtainable information on the processing of words presented in neutral sentential contexts, such as the carrier phrases used in the present research. This information provides a good indication of what stretch of the spoken signal is sufficiently constraining to reduce the set of words competing for identification to one, that is, the Actual Word. Additionally, the alternative responses produced at the various gates give some insight into the extent of the ambiguity of the signal, and into which words have become activated in the mental lexicon on the basis of the input. It is for these reasons that I have employed the gating paradigm here. It is used as an exploratory tool to obtain some basic data on the relative information value of the signal. The actual processing consequences of the informativeness of the signal need to be assessed by means of on-line research. This is the subject of the remainder of this thesis.

The processing of spoken words in neutral sentences

The first reaction-time experiment examines the on-line processing of the Actual Words in neutral sentences, containing no specific semantic or syntactic constraints for the Actual Words. Because each Actual Word is spoken in what is essentially a carrier phrase, the only real source of information available for the listener is the physical signal of the specific acoustic realization of the Actual Word.[2] The main purpose of the Carrier Phrase experiment is to investigate the temporal dynamics of the spoken-word recognition process, as a function of accumulating sensory information. The experiment taps into the stimulus processing event at different moments in time, probing words that have - possibly - become activated on the basis of the input, and assessing what the effect of continuing stimulus processing is on their activational status.

The experiment investigates three different moments in time in the processing of an Actual Word. The approach is to present the listener with a carrier phrase with the Actual Word in phrase-final position, and to vary the amount of signal - measured from word onset - that is presented of the Actual Word. Three different stretches of the acoustic signal are given as input to the listener, realizing the three different moments under investigation.

The first moment is meant to reflect the early phases of stimulus processing, in which some initial part of the incoming signal has been analyzed, but where the signal as such does not pinpoint a particular entry in the mental lexicon. The amount of signal involved here for each of the Actual Words has been operationalized by means of the gating study. This experimental condition is referred to as the *First bias condition*.

The second moment is intended to reflect a further phase of stimulus processing, where more of the signal has been analyzed, and where this analysis points towards one specific candidate word for recognition. Nevertheless, the signal as such is not fully deterministic. This amount of signal for each of the Actual Words has also been operationalized by means of the gating study, and the experimental condition is referred to as the *Actual Word bias condition*.

The final moment lies at the end of stimulus processing, where all of the incoming signal has been analyzed, i.e., where all of the word has been heard. All of the selected Actual Words were confidently identified by the last gate, by all subjects. This condition will be referred to as the *Full word condition*.

The processing consequences of the three signal conditions are examined by gathering reaction-time responses to target words, namely to the Actual Words as well as to their Gating or Dictionary Competitors. The pattern of reaction times obtained as a function of the amount of signal that has been processed, reflects the relative activation of the target words. This activational profile gives insight into the temporal dynamics of the ongoing stimulus processing, by providing evidence on the extent to which the target words are in competition for recognition, and at what moments in time. In the experiment to be reported here - and in all experiments to follow - the cross-modal candidate priming paradigm is used, in combination with a naming task. Reaction times are measured by means of a voice-operated relay that is sensitive to changes in the energy of sound-pressure waveforms. In the present experiment, reaction-time measurement began as soon as the target word was presented visually, and stopped as soon as the subject began to articulate the target word. I will refer to these timed responses as reaction times, naming times, or simply as latencies. The following example summarizes the six main experimental conditions of Experiment 1:

Auditory prime:	*Visual target*:	*Condition*:
Je hoort nu het woord beu	BEURT (Actual Word)	1
	BEURS (Competitor)	2
Je hoort nu het woord beur	BEURT	3
	BEURS	4
Je hoort nu het woord beurt	BEURT	5
	BEURS	6

Each of these six experimental conditions has a control condition. In the control condition, the subjects hear the same carrier phrases used for the Actual Word presentations, but the sentences end with words that are neither phonetically nor semantically related to the Actual Words or to their competitors. Following the presentation of a carrier phrase ending in a control word, the subjects see either an Actual Word or its competitor. Those experimental conditions which end in a fragment of the Actual Word, have as control conditions sentences likewise ending in partly produced final words. The control conditions serve to establish baseline reaction-time measurements for the visually presented Actual Words and competitors. Given that in the control conditions there is no relationship between the auditory prime and the visual target, the reaction-times to the targets are assumed to reflect solely the processing of the visual input under conditions similar to the test manipulations (i.e., carrier phrases and partial word primes).[3] These baseline reaction-times are compared with the reaction-times for the target words presented under the experimental priming conditions. The size of any observed reaction-time difference expresses differential activation as a function of the experimental manipulations.

Stimulus preparation
For the experimental conditions, the exact same acoustic realizations of the carrier phrases and the Actual Words were used as originally recorded for the gating study. Using the facilities of the Speech Laboratory of the Max Planck Institute for Psycholinguistics, three speech files were created for each Actual Word, one file for each of the three priming conditions. For the priming conditions ending in a segment of the Actual Word, the signal was cut off at the point defined by the gating study.

For the control conditions new recordings were made. These mirrored the recordings for the experimental items with respect to the carrier phrases used, and the relative distribution of these phrases over the phrase-final words. Each control prime, i.e., the word occurring in final position in the control carrier phrase, was matched for word frequency, grammatical class, and number of syllables with the Actual Word it was the control for. For the two control conditions ending in a partially produced word, the length of the segmented signal for the control prime corresponds exactly to the length of the signal of the segmented Actual Word it is the control for.

New recordings were also made for filler and practice items. A total of 30 filler and 30 practice sentences was used. These consist of the same carrier phrases as used in the experimental and control conditions. The phrase-final words have the same distribution over word frequency, grammatical class, and number of syllables as present in the experimental conditions. Ten of the filler and practice sentences end in relatively short segments of the phrase-final word, ten in relatively long segments, and ten end in fully produced words. The length of the signal for the short and long segments was defined as the mean length of the signal for the Actual Words in the First bias and Actual Word bias conditions, respectively. The filler and practice target words mirror the frequency, grammaticality, and syllabicity of the experimental target words. No semantic or phonetic relationship exists between the filler primes and their targets. In the case of the practice items, six visual targets match their auditory primes. This was done to expose the subjects during the practice phase to the kinds of matches that they would be receiving during the experimental session.

Experimental design
The experiment has three main factors. The first is the basic Test/Control comparison. The second is the length of the auditory prime, with three levels: First bias, Actual Word bias, and Full word. The third is the visual target, with two levels: Actual Word and Competitor. To ensure that each subject in the experiment only sees each target word once, a latin squares design was used, resulting in a total of 12 experimental conditions: 2 (Test/Control) X 3 (Prime Length) X 2 (Target).

The 48 Actual Words were rotated by conditions over 12 experimental versions, with each version having 4 Actual Words in each condition (subdivided into two sets of two words each, along the Gating/Dictionary nesting dimension). Following the rotation, the order of conditions within versions was randomized. The same randomization was used in all versions. Each visual target word occurred only once in each version, and each subject saw an equal number of targets in each of the 12 experimental conditions. Following the rotation, 24 of the 30 filler items were pseudorandomly dispersed among the test items. The remaining six fillers were used as startup fillers at the beginning of the test session, to stabilize subject responses following the break after the practice session. The order of the 30 practice items was determined by means of a random-number generator.

Procedure

Subjects were tested in groups of three. Each subject sat in a sound-attenuated booth, wearing closed-ear Sennheiser HMD-224 headphones with an attached microphone, at a distance of approximately 80 cm. from a projection screen. The auditory stimulation was played directly from computer disk into the headphones. The visual target words were presented via slide-projectors that were situated outside the booths. The targets were presented in uppercase, as white letters on a grey diffuse background. Intelligibility of the speech and visibility of the targets was judged to be sufficient by three experienced experimenters, and the subjects reported no difficulty in perceiving the stimuli.

The subjects were instructed to listen carefully to the auditory input, and to read out loud each word they saw, as soon as it was presented. Speed of response was emphasized, but subjects were additionally instructed to avoid making mistakes. Subjects were told that at random intervals they would hear a tone following their voiced response. This tone indicated that the subjects had to write down on a form in front of them the word they had heard at the end of the preceding sentence. This was done to ensure that the subjects would indeed attend to the auditory input. Eight written responses were required during the experiment, only to filler primes that were fully pronounced.

The experiment was controlled via a PDP 11/55 computer. Target words were visually presented immediately at the offset of the auditory input. Presentation duration was 200 milliseconds. The time between successive sentences was 6 seconds. Reaction-times were measured via voice-operated relays linked to the microphone attached to the subjects' headphones. Reaction-time measurement began at presentation of the visual target, and terminated at the onset of articulation by the subject. Subjects' naming responses were monitored on-line by the experimenter for errors. In addition, all responses were tape recorded.

One test session, including instruction and practice, lasted just under 20 minutes. Subjects reported having no difficulty in attending to the auditory stimulation whilst simultaneously focussing part of their attention on the projection screen.

Subjects
A total of 72 subjects was tested from the Max Planck Institute for Psycholinguistics student-subject pool, 6 subjects on each experimental version. None of these subjects had participated in the gating study. Subjects were paid Hfl 8.50 for their participation.

Data analysis
Two subjects in two different versions had to be rejected because of excessively long reaction times (well over 800 msec). To facilitate the statistical analysis, the data of one subject were deleted at random from each of the other versions, resulting in a total of 60 subjects, 5 per version.

There is a very small number of naming errors (that is, incorrect word productions, false starts, and hesitations): in total 31, which is a mere 1% of all the responses. These erroneous reaction times were set to zero in the data matrix. Means and standard deviations - excluding error responses - were computed over subjects for each of the 12 experimental conditions. These numbers were used to define outlier values. Within each condition, all numbers below or above the condition mean, plus or minus two times the condition standard deviation, were replaced by the mean plus or minus two times the standard deviation. There is a total of 137 outlier values, which is 4.7% of the data set. The outliers were evenly distributed across the 12 experimental conditions. Following the replacement of these values, the 31 error responses were replaced by the means over subjects for the condition in which each error occurred.

The updated data set was entered into two analyses of variance, one by subjects and one by items. The subject analysis is based on a fully factorial design. The item analysis is based on a mixed design, with crossed factors Test/Control and Prime Length, and with items nested within the factors Target (Actual Words/Competitors) and Gating/Dictionary.

Results
Table 3 lists the mean naming times over subjects by conditions.

Table 3: Carrier Phrase Experiment, mean naming latencies over subjects by conditions.

	Prime Length					
	First bias		AW - bias		Full word	
	Test	Cont	Test	Cont	Test	Cont
Actual Word	410	437	406	432	394	413
Gat. Comp.	418	442	406	429	426	422
Actual Word	425	432	412	433	391	425
Dict. Comp.	429	436	428	437	435	417

In the subject analysis, the factors Target, Prime Length, and Test/Control have significant main effects, and the interactions among these factors are all significant. The full statistics are as follows:

Target	$F_{1,59}$ =32.17	MSe=1324	p<0.01
Prime Length	$F_{2,118}$ =14.33	MSe=1792	p<0.01
Test/Control (T/C)	$F_{1,59}$ =53.84	MSe=1372	p<0.01
Target X Test/Control	$F_{1,59}$ =12.74	MSe=1311	p<0.01
Target X Prime Length	$F_{2,118}$ =14.44	MSe= 737	p<0.01
Prime Length X Test/Control	$F_{2,118}$ = 6.86	MSe= 987	p<0.01
Target X Prime Length X Test/Control	$F_{2,118}$ = 5.87	MSe=1139	p<0.01
Gat/Dict	$F_{1,59}$ = 6.61	MSe=1142	p=0.01
Gat/Dict X Target	$F_{1,59}$ < 1.00	MSe=1151	p=0.56
Gat/Dict X Prime Length	$F_{2,118}$ = 2.83	MSe= 973	p=0.06
Gat/Dict X Test/Control	$F_{1,59}$ = 7.63	MSe=1584	p<0.01
Gat/Dict X Prime Length X Test/Control	$F_{2,118}$ = 1.32	MSe=1271	p=0.27
Gat/Dict X Target X Test/Control	$F_{1,59}$ < 1.00	MSe=1650	p=0.46
Gat/Dict X Target X Prime Length	$F_{2,118}$ < 1.00	MSe=1510	p=0.48
Gat/Dict X Target X Prime Length X T/C	$F_{2,118}$ < 1.00	MSe=1483	p=0.61

As the results show, a significant main effect emerges for the Gating/Dictionary Competitor dimension, as well as for the first-order interactions with Prime Length (although marginal) and with Test/Control. However, these effects are not persuasive and should be treated with caution, for three reasons. First, and critically, the interaction with the factor Target is not significant. Second, the basic Gating/Dictionary Competitor comparison is essentially an item comparison, and its variance is more properly assessed via an item analysis. Finally, despite the main and first-order interaction effects in the subject analysis, the Gating/Dictionary Competitor dimension does not enter into any significant higher-order interaction with the other factors.

The analysis of variance by items shows no main effect for the Gating versus Dictionary Competitors. Furthermore, this dimension does not enter into significant interactions with the main factors of the experiment, barring an interaction with Test/Control. The relevant statistics are as follows:

Gat/Dict	$F_{1,92} < 1.00$	MSe=4230	p=0.40
Gat/Dict X Target	$F_{1,92} < 1.00$	MSe=4230	p=0.73
Gat/Dict X Prime Length	$F_{2,18} < 1.00$	MSe= 802	p=0.31
Gat/Dict X Test/Control (T/C)	$F_{1,92} = 3.87$	MSe=1124	p=0.05
Gat/Dict X Target X Test/Control	$F_{1,92} < 1.00$	MSe=1124	p=0.52
Gat/Dict X Target X Prime Length	$F_{2,184} < 1.00$	MSe= 802	p=0.47
Gat/Dict X Prime Length X Test/Control	$F_{2,184} < 1.00$	MSe= 669	p=0.41
Gat/Dict X Target X Prime Length X T/C	$F_{2,184} < 1.00$	MSe= 669	p=0.59

The factors Target, Prime Length, and Test/Control do have significant main effects in the item analysis. In addition, the interactions among these factors are all significant:

Target	$F_{1,92} = 3.88$	MSe=4230	p=0.05
Prime Length	$F_{2,184} = 12.57$	MSe= 802	p<0.01
Test/Control	$F_{1,92} = 24.27$	MSe=1124	p<0.01
Target X Test/Control	$F_{1,92} = 6.24$	MSe=1124	p=0.01
Target X Prime Length	$F_{2,184} = 6.01$	MSe= 802	p<0.01
Prime Length X Test/Control	$F_{2,184} = 3.92$	MSe= 669	p=0.02
Target X Prime Length X Test/Control	$F_{2,184} = 4.94$	MSe= 669	p<0.01

Overall, the analysis of variance provides very little, if any, evidence for a differential effect due to the Gating/Dictionary manipulation. It appears that the processing of the Competitor targets is unaffected by their status vis à vis the gating data. The only significant effect with Gat/Dict is the interaction with the factor Test/Control. This reflects the fact that the Gating items produce overall faster response times than the Dictionary items in the test conditions, whereas the two sets of items produce the same overall latencies in the control conditions (Gat/Control=429 msec, Dict/Control=428, Gat/Test=410, Dict/Test=420). However, these numbers are not particularly revealing because they collapse across Actual Words and Competitors, as well as across the three levels of the factor Prime Length. To appropriately assess this interaction effect, separate analyses of variance were performed for the Actual Words, and for the Gating and Dictionary Competitors.

For the Actual Words no significant main or interaction effects emerge with the Gating/Dictionary manipulation. This is as it should be, given that the Gat/Dict factor is relevant with respect to the Competitors, not with respect to the Actual Words. This analysis of variance for the Actual Words empirically validates the homogeneity strived for in the selection criteria used in the gating study, by demonstrating that the set of Actual Words linked with Gating Competitors, and the set of Actual Words linked with Dictionary Competitors, do not differ in their basic processing characteristics.

The separate analyses for the Gating and Dictionary Competitors provide an indication of the origin of the Gat/Dict by Test/Control interaction. The main effect of Test/Control is significant for the Gating Competitors ($F_2(1,23)=4.08$, $MSe=1743$, $p=0.05$), but not for the Dictionary Competitors ($F_2\ (1,23)<1.00$). This implies some kind of dissociation in the effects due to the Gating or Dictionary status of the Competitors. However, the main effect of Test/Control collapses over the three levels of the factor Prime Length, and a closer inspection of the data as a function of Prime Length reveals that the pattern of results for the two kinds of Competitors is closely similar, the main difference emerging in the relative strength of the effects for Gating and Dictionary. The Prime Length by Test/Control interactions for the Gating versus Dictionary items provide the critical test. Separate analyses of variance show that these two interaction terms are equally significant (Gating: $F_2(2,46)=4.67$, $MSe=631$, $p=0.01$; Dictionary: $F_2(2,46)=4.68$, $MSe=580$, $p=0.01$). In other words, when the full reaction-time profile as a function of Prime Length is taken into account, then it becomes apparent that despite an overall reaction-time difference with respect to the factor Test/Control, the Gating and Dictionary Competitors exhibit essentially the same differential effects with respect to the other main experimental factors. In conclusion, as was already clear from the overall analysis of variance results, the distinction between Gating and Dictionary Competitors does not result in differential processing effects.

Given that the item and the subject analyses provide no compelling statistical basis for the Gating/Dictionary Competitor dimension, this dimension was collapsed in the data matrix. Two new analyses of variance were run, one by subjects and one by items. The item analysis now has only one nesting dimension, namely Target. Table 4 lists the mean naming times over subjects by conditions. These data are also represented in Figure 1.

Table 4: Carrier Phrase experiment, mean naming latencies over subjects by condition, Gating/Dictionary collapsed.

	Prime Length					
	First bias		AW – bias		Full word	
	Test	Cont	Test	Cont	Test	Cont
Actual Word	417	434	409	432	392	414
Competitor	424	439	417	433	431	420

In the subject analysis of variance all main effects and interaction terms reach significance:

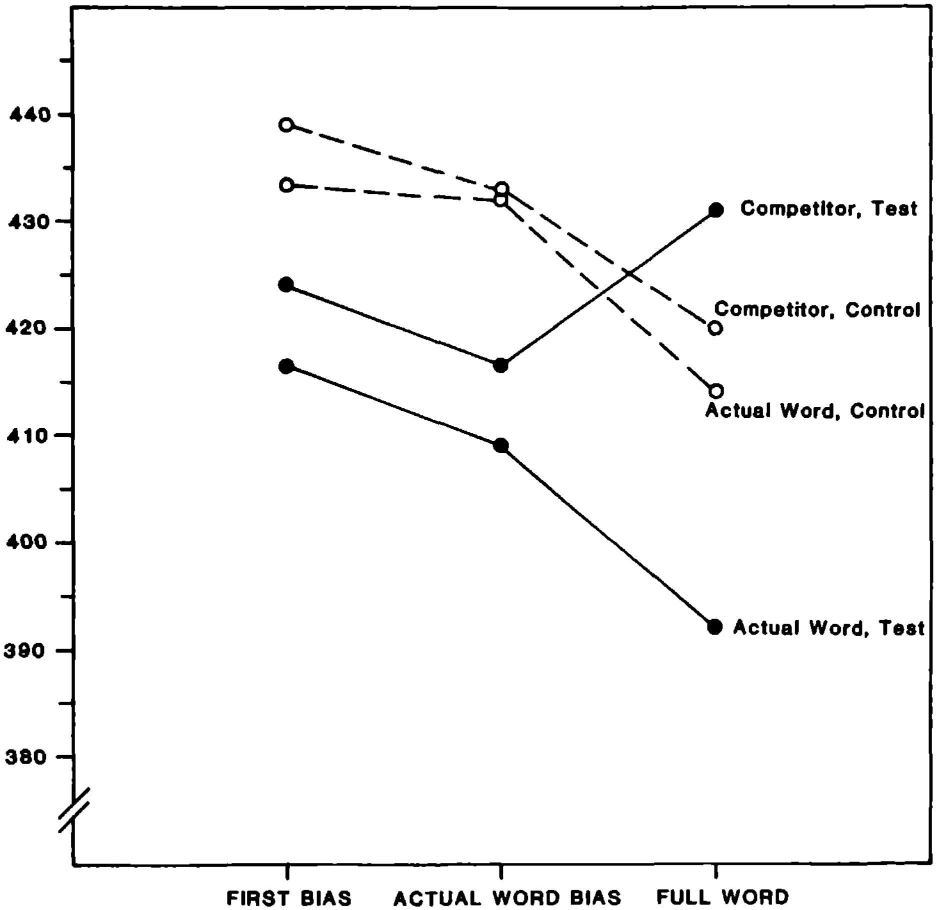
Target	$F_{1,59}=32.20$	MSe= 662	$p<0.0001$
Prime Length	$F_{2,118}=14.32$	MSe= 896	$p<0.0001$
Test/Control	$F_{1,59}=53.84$	MSe= 686	$p<0.0001$
Target X Test/Control	$F_{1,59}=12.70$	MSe= 656	$p=0.0007$
Target X Prime Length	$F_{2,118}=14.42$	MSe= 369	$p<0.0001$
Prime Length X Test/Control	$F_{2,118}=6.86$	MSe= 494	$p=0.0015$
Target X Prime Length X Test/Control	$F_{2,118}=5.88$	MSe= 570	$p=0.0037$

Likewise, in the item analysis, the three factors all show a significant main effect, as well as significant interaction terms:

Target	$F_{1,94}=3.93$	MSe=4178	$p=0.05$
Prime Length	$F_{2,188}=12.57$	MSe= 801	$p<0.001$
Test/Control	$F_{1,94}=23.69$	MSe=1151	$p<0.001$
Target X Test/Control	$F_{1,94}=6.10$	MSe=1151	$p=0.015$
Target X Prime Length	$F_{2,188}=6.01$	MSe= 801	$p=0.003$
Prime Length X Test/Control	$F_{2,188}=3.94$	MSe= 665	$p=0.021$
Target X Prime Length X Test/Control	$F_{2,188}=4.97$	MSe= 665	$p=0.008$

Separate item analyses of variance on the control conditions for the Actual Words and the Competitors show that there are no significant differences between the two kinds of targets at each of the three levels of Prime Length.

Figure 1: Mean naming latencies for Actual Words and Competitors, in test and control conditions, as a function of prime length.



This demonstrates that the Actual Words and Competitors do not differ under neutral control conditions. In other words, the attempted match between the targets on the various lexical characteristics described earlier in the section on stimulus selection has been successful, and in this respect the Actual Words and the Competitors are shown to be a homogeneous set of stimuli.

To complete the analysis of the data, an item analysis of variance was computed on the Test minus Control difference reaction-times (with the Gating/ Dictionary dimension collapsed). These differences reflect the relative effects of the match between the visual targets and their auditory primes, as a function of prime length. Table 5 lists the difference scores, averaged over subjects by items. A negative number indicates that a test condition resulted in faster reaction-times relative to its neutral control condition. These data are also represented in Figure 2.

Table 5: Carrier Phrase experiment, Test-Control difference scores averaged over subjects (Gat/Dict collapsed).

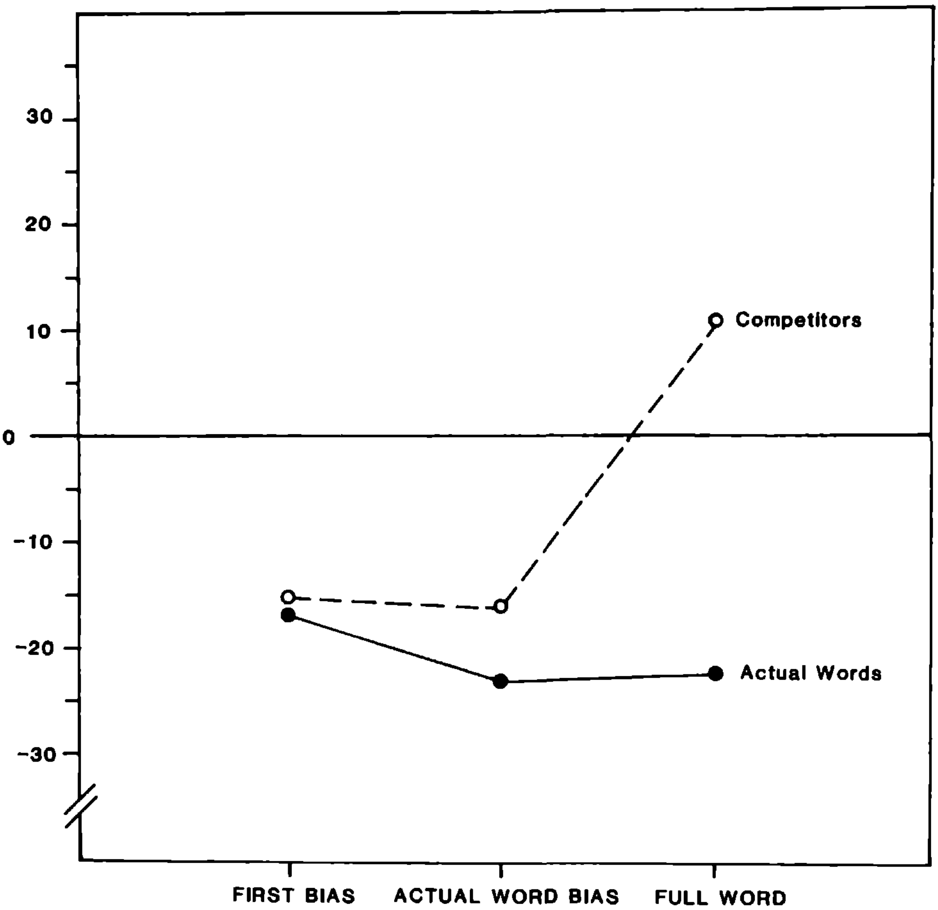
	Prime Length		
	First bias	AW – bias	Full word
Actual Word	- 17	- 23	- 22
Competitor	- 15	- 16	+ 11

As is to be expected on the basis of the results of the overall analysis of variance, the main effect of Target and of Prime Length is significant, as well as the interaction between them:

Target	$F_{1,94} = 6.10$	MSe=2302	p=0.015
Prime Length	$F_{2,188} = 3.95$	MSe=1330	p=0.021
Target X Prime Length	$F_{2,188} = 4.96$	MSe=1330	p=0.008

Separate analyses of variance on the subsets of data which enter into each of the cell numbers in Table 5, show that all of the differences scores represent significant deviations from the relevant control mean:

Figure 2: Test minus Control difference scores for Actual Words and Competitors in carrier phrases, as a function of prime length.



Actual Word	: First bias position	$F_{1,47}$ = 8.49	MSe=807	p=0.005
Actual Word	: AW-bias position	$F_{1,47}$ =15.13	MSe=868	p<0.001
Actual Word	: Full word position	$F_{1,47}$ =15.48	MSe=746	p<0.001
Competitor	: First bias position	$F_{1,47}$ = 6.84	MSe=859	p=0.015
Competitor	: AW-bias position	$F_{1,47}$ = 6.84	MSe=919	p=0.012
Competitor	: Full word position	$F_{1,47}$ = 3.75	MSe=764	p=0.058

Comparing the difference scores for the two targets at each of the levels of the factor Prime Length, reveals that the only significant separation between the Actual Words and the Competitors occurs at the Full word position ($F_2(1,94)=17.17$, MSe=1509, $p<0.01$). Separate analyses on the size of the transition effects going from either the First bias to the Actual Word bias position, or from the Actual Word bias to the Full word position, show that only the transition between the Actual Word bias and the Full word position for the Competitor targets reaches significance ($F_2(1,47)=15.84$, MSe=1114, $p<0.01$).

Discussion

Gating versus Dictionary Competitors

The first main result that has to be accounted for is the basic absence of an effect for the Gating/Dictionary Competitor distinction. The fact that the variable Target does have a significant main effect, and that it enters into significant interactions with the other main factors, demonstrates that the independent variables Prime Length and Test/Control are affecting the ongoing stimulus processing. However, the lack of an effect for the Gating/Dictionary variable shows that this particular dimension plays no significant role during the processing of the signal. What does this imply?

Above all, the null-effect indicates that the set of word candidates generated in the gating study does not fully represent the pool of candidates that has become activated as a function of the analyzed acoustic signal. The Dictionary Competitors were specifically selected to assess whether the actually produced alternative responses - i.e., the Gating Competitors - are indeed representative of the set of activated items. The present result shows that despite the fact that the Dictionary Competitors were not given as responses in the gating study, they do become activated on the basis of the analysis of the acoustic signal. One proviso has to be made here, and that is that it does seem that the Dictionary Competitors are less activated in each priming condition than the Gating Competitors; this issue will be further discussed below. However, the item analysis of variance - and the relevant interaction terms of the subject analysis - do not provide statistical support for a basic distinction between the two kinds of competitors. This finding has no real implications for the reaction-time research programme of this thesis. Apparently, the competitor level of the variable Target does not subdivide into two distinct classes of Gating versus Dictionary words. Therefore, from now on this variable can be characterized by two levels with no further subdivisions, namely Actual Words and Competitors.

The null-effect does, however, have clear implications for the importance and applicability of the gating paradigm for on-line processing research. As was already mentioned in the section on stimulus selection, the results reported by Zwitserlood (1989a) demonstrate that gating data are not a direct reflection of on-line language comprehension processes. The present results further undermine the idea that gating can provide substantial insights into the comprehension process as it unfolds in real-time, by showing that the set of responses generated in a gating procedure by no means captures all the words that have received activation from the incoming stimulus. This finding makes all the more clear that the immediate value of the gating procedure for on-line language research is restricted to the information it provides concerning which stretch of the signal enables isolated identification of a specific acoustic token of a word.[4]

In the results section of the gating study some reasons were discussed why the Dictionary Competitors were not produced as responses by the subjects. One of these reasons concerned the possibility that the subjects were picking up on subtle coarticulatory cues that favoured a match with the Gating over the Dictionary Competitors. Whether the assumed coarticulatory disparities in the match between the Gating and Dictionary Competitors and the incoming signal are equally exploited by the subjects tested with the on-line research procedure used in this dissertation, is a separate issue. The overall null-result for the Gating/Dictionary Competitor variable, and the associated non-significant interaction terms, do not argue in favour of such on-line effects. Nevertheless, as was already mentioned in the proviso made above, it is the case that for the First and Actual Word bias priming conditions, the processing effects for the Dictionary Competitors are smaller than those for the Gating Competitors. This could be a reflection of the fact that the subjects are picking up on relevant coarticulatory information, with the Dictionary Competitors turning out to be the poorest matches. However, given that the difference in the processing effects between the Gating and Dictionary Competitors is only some 10 milliseconds - which is non-significant - such coarticulatory influences seem unlikely. Moreover, to the extent that differences exist, these are mirrored in the set of Actual Words: here there is a tendency for the Actual Words linked with Gating Competitors to be somewhat faster than the Actual Words linked with Dictionary Competitors. In other words, any variability at the level of the Competitors is balanced by an analogous variability at the level of the Actual Words (it should be recalled that the factor Gat/Dict had no significant effect in the separate analysis of variance on Actual Words, so no firm statements can be made). In the next sections, the effects of the independent variables Test/Control and Prime Length will be discussed for the data with the Gating/Dictionary Competitor variable collapsed (this level of the Target variable will from now on be labeled Competitor).

The control conditions

A first remark concerns the reliability of the control conditions for the Actual Words and Competitors. In the control conditions, the subjects heard a carrier phrase ending in (segments of) a word that was in no way related to the visually presented Actual Word or Competitor. The underlying rationale was that in the control conditions the naming latencies should be a sole reflection of the processing time for the visual targets, uncontaminated by the processes under investigation in the test conditions. If this is the case, then the prediction is that the reaction times in the control conditions should not differ as a function of either the variable Target or the variable Prime Length (this prediction assumes that the Actual Words and their Competitors are appropriately matched for lexical characteristics, such as word frequency).

As was shown by the analyses reported above (see Table 4 and Figure 1), for the first two Prime Length conditions (i.e., First bias and Actual Word bias) the prediction is upheld. The reaction times are very closely matched (First bias, Actual Word vs. Competitor: 434 vs. 439 msec; Actual Word bias, Actual Word vs. Competitor: 432 vs. 433 msec). However, the reaction times in the Full word priming control conditions are appreciably faster (Actual Word: 414 msec, Competitor: 420 msec). The difference for the Actual Words between the Actual Word bias position and the Full word position is 18 msec, which is significant ($F_2(1,47)=13.02$, $MSe=618$, $p<0.01$). The difference for the Competitors is 13 msec, which is also significant ($F_2(1,47)=5.98$, $MSe=684$, $p=0.02$). I do not believe that these two faster reaction times imply that the control condition is in some way flawed. The faster times following the full presentation of the auditory prime reflect a basic processing effect due to stimulus certainty. The Full word condition differs from the two other priming conditions in that the subjects have full information concerning which word has been auditorily presented. In contrast, the partial priming conditions create a basic uncertainty with respect to which word is being heard. This uncertainty adds to the processing load during stimulus processing, and this is reflected in overall slower response times.

If it were the case that not stimulus uncertainty, but simply stimulus length is affecting the ongoing processing, then it follows that the two segment priming control conditions should be different, with the Actual Word bias condition resulting in overall faster times than the First bias condition.

As was already pointed out, this is not the case: the four means do not differ. This supports the distinction being made here between situations of stimulus certainty and uncertainty. In this respect it is important to note that the mean reaction times for the Actual Words and Competitors in the Full word priming condition do not differ from each other, which shows that the two levels of the variable Target are not differentially affected by stimulus certainty. Related to this aspect of the data, the results show that the Actual Words and their Competitors lead to identical response latencies in each of the control conditions. As was pointed out earlier, this demonstrates that the attempts described in the section on stimulus selection to control for the lexical characteristics of the target words (e.g., word frequency neighbourhood effects) have been successful. The Actual Words and their Competitors are a homogeneous set of target words.

Prime length and stimulus processing

The effects of the auditory priming conditions on stimulus processing are best discussed on the basis of the Test minus Control difference scores reported in Table 5. These difference scores control for the basic processing effects of the targets in neutral stimulus environments, and, therefore, reflect the real experimental effects. As was reported in the results section, each of the cell numbers of Table 5 represents a statistically significant deviation from a neutral control mean.

At the First bias position both the Actual Words and their Competitors have become activated on the basis of the acoustic input. Moreover, they are activated to the same degree. This provides evidence for multiple activation of entries in the mental lexicon, and demonstrates that at the point in time determined by the length of the signal in the First bias condition, the signal as such is insufficiently informative to distinguish between the Actual Word and its Competitor. In effect, the subjects cannot pinpoint the word they are listening to, and cannot yet differentiate between the two lexical candidates. In addition, the equal activation of the two targets once again underscores their lexical similarity.

At the Actual Word bias position both target words are still activated. With the increase in stimulus information, the activational pattern for Actual Words and their Competitors starts to separate, with the activation for the Actual Words increasing marginally, but the Competitors are still active candidates for recognition. In fact, the activational status of the Competitors has not changed, whereas the 7 msec increase in activation for Actual Words does not reach statistical significance compared to the Competitor. It seems then that the Actual Word bias condition does not produce a clear separation in the activational status of the two kinds of targets. The data are indicative of a bias for the Actual Words, but not conclusive.

At the Full word position the activational picture is quite different in comparison with the two previous time-frames. The Actual Words remain at a steady level of activation. The fact that compared to the Actual Word bias position, the Actual Words receive no further activation when their full word-form is presented as a prime, can be interpreted as evidence that the lexical selection process had already focussed - possibly at or just following the Actual Word bias position - on the particular Actual Word as the most likely candidate for recognition. Further confirming information serves to inhibit competing lexical entries, not to additionally increase an already sufficiently activated lexical candidate. The existence of an inhibitory process is supported by the difference reaction-time for the Competitor targets. Following full word presentation, the responses to the Competitor targets are significantly slower than the responses to the Actual Words ($F_2(1,94)=17.17$, $MSe=1509$, $p<0.01$), and, in fact, significantly slower with respect to the responses in all other experimental conditions.

Conclusions

A first conclusion that can be drawn is that the combination of a cross-modal candidate priming paradigm with a naming task is a valid research procedure to investigate on-line lexical processing. This was by no means apparent at the time the experimental programme reported here was initiated; this particular experimental configuration has been neither systematically used nor explored in psycholinguistic research.

The main conclusion is that the overall pattern of results provides evidence for differential activation of multiple lexical candidates as a function of the accumulating sensory information. The data paint a clear and revealing picture of the temporal dynamics of the lexical identification process. At first, multiple - and in the present research equal - activation of competing word candidates at early moments in time during stimulus processing. Next, a beginning of activational separation between candidates on the basis of further stimulus processing. Finally, suppression of inappropriate candidates and sustained activation of the selected lexical entry. This evidence for multiple activation of different entries in the mental lexicon on the basis of partial stimulus information, is in agreement with research described by Marslen-Wilson (1987), and with results reported by Zwitserlood (1989b) using a cross-modal semantic priming paradigm with a lexical decision task. The present data - gathered with a new paradigm and with a naming task - are a further source of direct evidence concerning the temporal dynamics of the on-line processing of spoken words.

The picture I have obtained provides information on some basic characteristics of the lexical processing system, but it is restricted to the domain of words spoken in neutral carrier phrases. To further increase our insight into the language comprehension system the next logical step is to investigate the processing of words in meaningful sentential contexts. This is the subject of the following chapter.

3 AUDITORY LEXICAL PROCESSING IN CONSTRAINING CONTEXTS

The research reported in this chapter compares the effects on spoken-word processing of manipulating different kinds of contextual environments. One comparison focusses on sentential-semantic contexts, the other on lexical-semantic contexts. In addition to manipulating sentential- and lexical-semantic information, the length of the signal of the word in discourse-final position is also varied, in the same way as was done in the reaction-time experiment presented in Chapter 2. The reasons discussed there for this manipulation also apply here: by controlling the amount of acoustic input the listener has received at the moment in time at which a response is required, an attempt is made to tap into the various on-line events that occur during spoken-word processing. The research tries to delineate the moments in time during the processing of a spoken word at which the manipulated contextual information exerts an effect, and as such, it is directed towards pinpointing the locus of contextual effects within the functional model of the on-line processing of spoken words that was outlined in Chapter 1. The approach is the same as used in the previous reaction-time experiment. Subjects are presented with spoken sentences which end in (segments of) an Actual Word. Immediately at the offset of the auditory stimulation, the relevant Actual Word or Competitor is visually presented, and the subjects have to read this word out loud as soon as they see it.

The sentential-semantic contexts consist of triplets of spoken sentences ending in an Actual Word that is a natural and meaningful completion of the discourse. Sentential-semantic constraints are defined as meaning restrictions concerning which words can occur in triplet-final position, where these restrictions arise from the overall meaning of the preceding discourse. What primarily determines the sentential-semantic nature of the meaning restrictions, is the fact that they cannot be readily attributed to the specific meaning of any one particular word in the sentences. The constraints arise at least in part from the implications of the real-world situation described by the discourse. These pragmatic implications are not linguistic in nature, but refer to an understanding of states of affairs in the world, to notions of causality and veridicality, to encyclopaedic as opposed to dictionary knowledge (cf. Johnson-Laird, 1983; Levinson 1983; Lyons, 1977; Seuren, 1985). Although the overall meaning is in part determined by the listener's grasp of the semantics of the individual words in the discourse, the listener's pragmatic knowledge is of central importance in constructing an ultimate representation of the utterance.

The research contrasts the effects of two differently constraining sentential contexts on the processing of the Actual Words and their Competitors. In what I refer to as the *Neutral Contexts*, the Actual Words and the Competitors are neutral and acceptable endings of the sentence triplets, but they are in no way predictable completions. In the *Constraining Contexts*, the discourse moderately restricts which words can occur in final position, thereby creating a certain bias for a given Actual Word, without making it heavily predictable. At the same time, the Competitor, although not anomalous, is a semantically inappropriate completion (more precise operationalizations and validations of these two kinds of contexts will be given in the stimulus selection section below). The following two triplets of sentences exemplify the distinction being made here between neutral and constraining contexts.[1]

Neutral Context

Iedereen was zeer gemotiveerd om er het beste van te maken.
De mannen waren de hele dag druk bezig.
Een van hen kocht een b / ba / bad. Target: BAD / BAL

Constraining Context

Het sanitair in de villa was nodig aan vervanging toe.
De mannen waren de hele dag druk bezig.
Een van hen kocht een b / ba / bad. Target: BAD / BAL

In the Neutral Context, the final word is a semantically acceptable completion of the discourse, but nothing in the sentences as such gives rise to any expectation that either the word 'bad' or 'bal' will actually appear. In the Constraining Context, the insertion of the noun 'sanitair' serves to focus the discourse on a real-word situation in which the Actual Word 'bad' is not only an acceptable, but also a moderately predictable completion. The Competitor target 'bal' is not an anomalous completion, in the sense that it does not violate the preceding semantic information (i.e., it is in fact possible that a man bought a ball), but it is highly implausible given the pragmatic implications of the real-world situation described by the discourse. A comparison of the naming latencies to the Actual Word and Competitor target words when they are presented following neutral and constraining contexts, will provide data on the effects of sentential-semantic information on spoken-word processing, as well as insights into the possible locus of such effects.[2]

The lexical-semantic contexts are realized within the discourse frames provided by the sentential-semantic manipulations. That is, these contexts consist of the same triplets of sentences of the Neutral Contexts ending in Actual Words. However, the effects of lexical-semantic context are not assessed via the Actual Words, but via their Competitors. This is achieved by varying the semantic relation between the visually presented Competitor and the verb that immediately precedes the triplet-final word. The manipulation entails either a preceding verb which is semantically neutral and non-predictive with respect to the visual target word, or a verb which results in combination with the Competitor in a semantic anomaly. This anomaly arises from a conflict between the semantic information associated with the argument-structure of the verb (cf. Bresnan, 1982; Carlson & Tanenhaus, 1987; Chomsky, 1965; Jackendoff, 1972; Stowe, 1989) and the semantics of the word which is grammatically linked in the discourse with that verb. The underlying idea is that if listeners exploit information contained in the argument-structure of verbs to facilitate the processing of an immediately following spoken word (and there is evidence from on-line identical-word monitoring data that listeners do, cf. Marslen-Wilson, Brown, & Tyler, 1988), then violating this information should be detrimental to the ongoing process. If this is the case, then it will show up in on-line tasks - such as naming - in an increased latency relative to the latency for processing a word that is preceded by a semantically neutral verb. The following two triplets provide an example of this lexical-semantic comparison.

Neutral Verb

Iedereen was zeer gemotiveerd om er het beste van te maken.
De mannen waren de hele dag druk bezig.
Een van hen kocht een b / ba / bad. Target: BAD / BAL

Anomalous Verb

Iedereen was zeer gemotiveerd om er het beste van te maken.
De mannen waren de hele dag druk bezig.
Een van hen installeerde een b / ba / bad. Target: BAD / BAL

In the Neutral Verb discourse, both the sentence-final Actual Word and its Competitor (i.e., bad-bal) are semantically acceptable and neutral completions. This is not the case in the Anomalous Verb discourse. Here the Competitor target is semantically anomalous with respect to the preceding verb 'installeerde' (to install). The anomaly evolves from the lexical-semantics of the verb, in relation to the meaning of the target. By comparing naming latencies to the visual targets in the Neutral and in the Anomalous Verb discourses, information can be obtained on the extent to which listeners exploit this kind of lexical-semantic information during on-line processing.

Sentential-semantics and lexical-semantics can be seen as representing two qualitatively distinct but nevertheless closely linked sources of information for the listener. Distinct, because they lie on opposite sides of the division between non-linguistic and linguistic knowledge. Linked, because it is only by combining these two sources of information that the listener can compute a definite mental representation of the perceived utterance. Sentential-semantics and lexical-semantics are at the same time both independent and interdependent with respect to each other. Given this complex relation, an experiment was designed to simultaneously investigate both the separate and the combined effects of sentential and lexical contexts. For reasons that will become clear in the section on stimulus selection, the number of Actual Word and Competitor target-pairs available is too small to allow for a fully factorial within-subject design. Therefore, the sentential-semantic manipulation of Neutral Contexts and Constraining Contexts is realized in a between-subject comparison, whereas the lexical-semantic manipulation of Neutral Verbs and Anomalous Verbs is realized in each sentential context as a within-subject comparison. The following list provides an example of the full set of contextual manipulations.

Neutral Context

Neutral Verb

Iedereen was zeer gemotiveerd om er het beste van te maken.
De mannen waren de hele dag druk bezig.
Een van hen kocht een b / ba / bad. Target: BAD / BAL

Anomalous Verb

Iedereen was zeer gemotiveerd om er het beste van te maken.
De mannen waren de hele dag druk bezig.
Een van hen installeerde een b / ba / bad. Target: BAD / BAL

Constraining Context

Neutral Verb

Het sanitair in de villa was nodig aan vervanging toe.
De mannen waren de hele dag druk bezig.
Een van hen kocht een b / ba / bad. Target: BAD / BAL

Anomalous Verb

Het sanitair in de villa was nodig aan vervanging toe.
De mannen waren de hele dag druk bezig.
Een van hen installeerde een b / ba / bad. Target: BAD / BAL

What are the possible processing consequences of these various contexts? In the following, I will discuss the predictions that are made by different kinds of language processing models. The discussion will first focus on the effects of lexical-semantic information within the Neutral and the Constraining Contexts, followed by a discussion of the differential effects of sentential-semantic information.

Predictions for the Neutral Contexts

In the Neutral Verb environments, the acoustic input of the prime is basically the only real source of information that will enable the listener to distinguish between the Actual Word and its Competitor (this assumes that both targets are equally predictable given this particular context, an issue that will be addressed in the section on stimulus selection). In terms of the predicted processing effects, this context closely resembles the previously reported Carrier Phrase experiment. The predictions are, therefore, that initially - i.e., at the First bias position - both the Actual Word and its Competitor will be equally activated. Following this initial multiple activation it is to be expected that at or around the Actual Word bias position, the activational status of the two word candidates will start to diverge, ultimately resulting in the suppression of the mismatching Competitor candidate.

In the Anomalous Verb environments, the listener is confronted with an additional source of information next to the acoustic input of the prime, namely the lexical-semantic information contained in the pre-target verb (of course, such information is also available with Neutral Verbs, but there the information can have no differential impact). With respect to the Actual Word target, the semantical relationship with the Anomalous Verb does not differ from that with the Neutral Verb. So, the predictions made there concerning the processing of the Actual Word apply equally here. In fact, if the same pattern of results emerges, then this empirically verifies that the specific verbs used in the Neutral and Anomalous Verb manipulations do not, as such, elicit any differential processing effects. A more interesting situation arises for the Competitor targets. Here, the lexical-semantic information of the verb conflicts with that of the target. The predictions of what processing effects will result from this conflict, depend on the kind of general on-line processing model that is assumed to apply for spoken language understanding.

Fully interactive, so-called all-or-none models, posit that any source of relevant information can and will immediately affect the ongoing process (cf. Grosjean, 1980; Morton, 1969, 1979). Although such models have lost some of their credibility in the light of evidence for the multiple activation of different meanings of ambiguous words irrespective of sentential context (e.g., Seidenberg et al., 1982; Simpson, 1981, 1984; Swinney, 1979), it is nevertheless worthwhile to investigate their predictions with respect to the contextual manipulations realized in the present research. The reason is that the data that will be reported here are not obtained via the semantic priming paradigm which has so dominated the research on lexical ambiguity in particular, and multiple activation in general. The research programme of this dissertation is based on candidate priming, and, therefore, it provides a different empirical perspective on the validity of all-or-none interactive processing models.

To the extent that all-or-none models distinguish between processes of lexical access, selection, and integration, the claim is that all of these processes are open to the impact of information from anywhere within the processing system. The prediction, therefore, is that the Competitor will not become activated at all on the basis of the acoustic input of the prime. The reasoning is that the listener accesses the semantic information associated with the verb, and uses this information in real-time to restrict the lexical space from within which following words can be expected to occur. So, the straightforward prediction for the Competitors is that their latencies will be constant, merely reflecting the processing of the visual stimulus. In comparison with the Neutral Verb environments it is predicted that the latencies for the Competitors will be increased.

A related class of interactive models - which for the sake of terminological clarity I will refer to as interactive-activation models - also posits that any relevant information can affect the ongoing analysis process, but unlike the all-or-none variants these models (exemplified in the research by McClelland & Rumelhart, 1981, and McClelland & Elman, 1986) posit a continuous flow of information between stimulus analysis and top-down information. To some extent, these models adhere to the primacy of the signal, in that they allow activation to flow to word candidates on the basis of stimulus processing, even if these candidates are inappropriate in the light of higher-order information. Although to date there are no explicit algorithms available which compute the actual activational processing consequences of conflicting stimulus and higher-order information, it is clear that these kinds of interactive models must claim that the activational level of the Competitors will be significantly reduced in the Anomalous Verb compared to the Neutral Verb environments. Moreover, these models predict an interaction effect between the length of the acoustic prime and the Anomalous versus Neutral Verb manipulation (i.e., the combined effects of Prime Length and Verb Type should not be additive).

Within so-called fully autonomous processing models (Forster, 1979; Marslen-Wilson, 1987; Seidenberg, 1985; Tanenhaus, Carlson, & Seidenberg, 1985), the assumption is made that the analysis of the signal and the unique identification of the presented word is the result of a modular process. The domain of the process is taken to be restricted to either a (sub)lexical space of frequency-weighted form representations (cf. Forster, 1976), or to the mental lexicon, which includes lexical-semantic and syntactic information (cf. Seidenberg, 1985). The modular nature of the process is reflected in the claim that processes within the module are unaffected by information that is represented at other levels in the language system. In particular, it is claimed that sentential-semantic information cannot influence either lexical access or selection. Lexical access is seen as the sole result of an analysis of the signal, unaffected by sentential-semantic, lexical-semantic, or syntactic information. Lexical selection, although largely determined by the bottom-up sensory information, can be influenced by other factors. Forster's serial search model (Forster, 1976, 1979) adds word-frequency as a further source of information. Other variants include information encoded in semantic links between different entries in the mental lexicon (e.g., Seidenberg, 1985; Seidenberg, Waters, Sanders, & Langer, 1984). The predictions made by autonomy models for the processing of the Competitors in Anomalous Verb environments evolve, therefore, from a combination of the particular processing nature of the model, with the particular assumptions that are made with respect to the content of the domain within which lexical processing occurs.

All autonomy models predict that the Competitors will become available on the basis of the analysis of some initial stretch of the acoustic prime, despite the preceding Anomalous Verb. The processing effect is predicted to be equal to that observed in the Neutral Verb environments. Given the results of the first reaction-time experiment, the hypothesis is that this initial stretch is to be equated with the First bias position. The predictions concerning the processing of the Competitor following the First bias position differ according to the assumptions concerning the content of the lexical processing domain. If a frequency-weighted set of form representations is assumed, then the semantic information of the preceding verb cannot affect the ongoing processing of the stimulus. Therefore, the predictions become the same as those for the Neutral Verb environment: continued processing beyond the First bias position, followed by suppression caused by the mismatch between the stimulus information of the prime and the target. If a more substantial domain is assumed, i.e., a mental lexicon with lexical-semantic and syntactic information, then the Anomalous Verb will adversely affect the processing of the Competitor, but only if it is claimed that the relevant semantic information is encoded in the lexicon. If this information is encoded, then the prediction is that the activational level of the Competitors will be suppressed, compared to their level in the Neutral Verb environments. Given the previous reaction-time results, the hypothesis is that this suppression effect will arise around the Actual Word bias position, and will certainly have occurred before the Full word position (where suppression is expected to occur anyway, because of the mismatching stimulus information).

Predictions for the Constraining Contexts

For the fully interactive models, both the all-or-none and the less exacting interactive-activation variants, the predictions for the processing of the Actual Words in the Neutral and Anomalous Verb environments are the same as those made above for the Neutral Contexts: no processing differences are to be expected.

In Neutral Verb environments it is predicted that given the available sentential-semantic information, the activational level of the Actual Words will separate from that of their Competitors, because these are semantically inappropriate candidates. It is unclear whether the all-or-none models predict that the Competitors will not become activated at all - these models do not explicate the effects of contextual constraints on activational levels - but it is in accordance with the spirit of these models to claim that this should indeed be the case. Within the approach advocated by McClelland and Elman (1986), some activation of the Competitors is presumed to occur at the First bias position, due to the compatibility of the form-representation of the Competitors with the analyzed acoustic input. Following their activation, the prediction is that the divergence, over time, between Actual Words and Competitors will be different compared to the Neutral Contexts with Neutral Verbs. The extent of this divergence is dependent on the severity of the sentential-semantic constraints. Given that these are quite moderate (for details see the stimulus selection section), it can be expected that the full-scale interference effect observed in the first reaction-time experiment will not be observed at bias positions before the Full word position.

For the Anomalous Verb environments the prediction on the basis of all-or-none models is once again that the Competitors will not receive any activation at all from the prime, because they will already have been suppressed on the basis of the semantic information of the preceding verb. For the interactive-activation models the same basic picture applies as presented for the Neutral Verb environments: a suppression effect due to the sentential-semantic information is predicted, and this effect will increase with increasing stimulus information of the prime. In addition, it can be claimed that there will be a further effect due to the information of the Anomalous Verb, resulting in an overall larger suppression of the Competitors in the Anomalous Verb environments compared to the Neutral Verb environments.

This additional prediction presupposes that the processing consequences of the sentential-semantic and lexical-semantic information can combine over time. However, given that in the current contextual manipulations the sentential-semantic information builds up over stretches of time well preceding the lexical-semantic information, it is also possible that the impact of the sentential-semantics has already accrued to such an extent that the lexical-semantic information has no additional role to play. Again, such subtleties are not explicated in the current literature on interactive-activation models, but the overall thrust of these models is in the direction of accumulative activational effects.

The predictions for the fully autonomous processing models are straightforward. Given that these models deny that sentential-semantic information can affect the processes of lexical access and selection, the exact same predictions as discussed for the Neutral Contexts also apply here. One additional, albeit not central, prediction can be made concerning the pattern of responses following the Full word priming condition. All models agree that certainly at this point in time lexical selection has been completed and, therefore, the integration of the identified word within the preceding discourse can take place. According to the autonomous models, it is only now that sentential-semantic information plays a role in the ongoing processing. Moreover, some models (e.g., Forster's serial search model) posit that it is also only now that the semantic constraints of the preceding verb can exert an effect. It can, therefore, be predicted that the interference effect for the Competitors following the Full word priming condition will be larger in the Anomalous Verb than in the Neutral Verb environments. This prediction also holds true for the Competitors when presented in the Neutral Contexts. In both cases, the underlying assumption has to be that the naming task in combination with cross-modal candidate priming is sensitive to post-selectional integration effects.

Predictions comparing Neutral and Constraining Contexts

A further set of predictions concerns the relative effects of the sentential-semantic manipulations on the processing of the Actual Words and their Competitors. These predictions do not evolve from autonomous processing models - since they prohibit any effects of sentential-semantics on lexical processing - but concern claims made by interactive processing models. All variants of these models must predict that the Actual Word will receive more activation in the Constraining Contexts compared to the Neutral Contexts. In the all-or-none models, this effect should obtain before any stimulus processing of the target word has occurred. Therefore, these models predict a significant difference for the Actual Words between the Constraining and Neutral Contexts at the First bias position. Given the further claim of all-or-none models that word recognition can and will proceed without any actual stimulus information of the word, an additional prediction of these models could be that there will be no differential effect due to increasing stimulus information. That is, the effect of sentential-semantics will be established by the First bias position, and will remain constant over the Actual Word bias and Full word positions. Again, this additional prediction depends on the claims that are made concerning the overall impact of differently constraining sentential-semantic information on word activation, and this aspect of these models has not been worked out in sufficient detail in the literature.

The interactive-activation models assign more importance to the incoming stimulus information. Although, as mentioned earlier, these models do not provide explicit activational algorithms concerning the interaction of stimulus and higher-level information, they clearly do claim that the activational status of the Actual Word will result from an interaction of the available acoustic and sentential-semantic information. Therefore, the prediction for these models is that not only will the Actual Word receive more activation in the Constraining Context compared to the Neutral Context, but also that the activation of the Actual Word will increase as a function of prime-length. It is unclear whether this increase is predicted to be a simple additive effect or a true interaction. In both cases, the effects of prime-length should be more substantial in the Constraining Contexts.

With respect to the Competitors, all interactive models claim that the activational level of these words should be more suppressed in the Constraining Contexts, compared to the Neutral Contexts. The all-or-none models predict that the suppression effect is a constant, unaffected by prime length or verb environment. For the interactive-activation models prime length is an additional factor. It can be further claimed by these models that given the additional negative evidence from the lexical-semantic information in the Anomalous Verb environments, the size of the suppression effect will be larger than the effect predicted for the analogous Neutral Contexts.

Stimulus selection and preparation

The 48 Actual Words with their Competitors provided the lexical set around which the various discourses had to be constructed. For any given pair of targets, four sentence-triplets were required: Neutral Context with Neutral Verb, Neutral Context with Anomalous Verb, Constraining Context with Neutral Verb, and Constraining Context with Anomalous Verb. The following list recapitulates the defining characteristics of these contextual manipulations.

1. All discourses consist of triplets of sentences ending in (segments of) Actual Words.

2. The Actual Word targets and their Competitors are syntactically correct completions of the discourse-final sentences.

3. The distinction between Neutral and Constraining Contexts is realized only by changing the first sentence of each triplet.

4. The second sentence of each triplet is identical for all discourses, irrespective of contextual manipulation. The only function of this sentence is to create temporal distance between the first and the final sentences of the Constraining Contexts. In particular, the second sentence separates those words in the first sentence which serve to instantiate the semantic focus for the Constraining Contexts, from the Actual Word and Competitor targets which follow the discourse-final acoustic prime.[3]

5. The distinction between Neutral and Anomalous Verbs is realized only by changing the verb immediately preceding the discourse-final word. This distinction only applies to Competitor targets. The same neutral and anomalous verbs are used in Neutral and Constraining Contexts.

6. The Neutral Contexts with Neutral Verbs are discourses in which both the Actual Words and their Competitors are semantically acceptable but not predictable completions. None of the content words in a given discourse has a close meaning relation with either the Actual Word or the Competitor that is presented with that discourse.

7. The Neutral Contexts with Anomalous Verbs create a semantic anomaly in combination with the Competitor target (and remain neutral and acceptable with respect to the Actual Word).

8. The Constraining Contexts with Neutral Verbs create a sentential-semantic bias for the Actual Word, but do not make it overly predictable. The Competitors are semantically inappropriate given the discourse.

Obviously, the target words constrain to a large extent what possibilities there are to construct specific sentential-semantic and lexical-semantic contexts. Given that the initial selection of the Actual Words and their Competitors was dictated by their matching form-representations in combination with the gating response profiles for the Actual Words, it is perhaps not surprising that it proved impossible to create discourses as defined above for the full set of 48 target-pairs. Following considerable effort by a number of people well-versed in the intricacies of making stimuli for psycholinguistic research, discourses were created for a total of 28 Actual Word and Competitor target-pairs.

To assess the extent of the contextual constraints, a number of cloze tests was performed on the Constraining and Neutral Contexts with Anomalous Verbs.[4] Subjects were presented with written versions of the individual discourses, with the final word omitted. Their task was to write down what they thought was an appropriate completion, given the overall meaning of the preceding sentences. Each cloze test consisted of two versions. In each version only one context for a particular target-pair occurred, so that Constraining and Neutral Contexts were evenly distributed between versions. The following criteria were used to select the definite set of discourses for the experiments.

1. No subjects should respond with the Competitor in either the Constraining or the Neutral Contexts. This is a requirement because the Anomalous Verb should not allow Competitor targets to occur within its semantic scope.

2. No subjects should respond with the Actual Word in the Neutral Contexts, nor with words related in meaning to the Actual Word. This is a requirement because the Neutral Contexts should in no way specifically constrain the semantic field to that associated with the Actual Words.

3. On average, 20% of the subjects should respond with the Actual Word in each Constraining Context, with a permissable range of 10%. This cloze-value is an operationalization of the constraining effect of sentential-semantic information. The cloze-value is set quite low, because higher values (say within the 50% range) would open the way to interpreting any observed sentential-semantic effect as being the result of some predictive strategy by the listener, which could take place without any analysis of the signal of the discourse-final prime. Such an interpretation would by-pass a processing explanation where sentential-semantic information is actively engaged in the processing of the word stimulus (cf. Forster's (1981) concept of 'sophisticated guessing').

Following the first cloze procedure, the discourses were slightly adapted and tested again. The results of the second cloze test necessitated further adaptations of the material, and, hence, a third procedure. In all, 120 subjects were tested, 20 on each version in each cloze test. The final result of these cloze tests, applying the criteria just mentioned, is a set of discourses for 24 target-pairs. These serve as the experimental material for the reaction-time research to be reported. They are listed in Appendix 2.

In addition to the experimental discourses, 36 filler and 32 practice discourses were created. The fillers consist of 12 sets of one sentence, 12 of two sentences, and 12 of four sentences. This variation in the length of the discourses ensures that the subjects cannot build up an expectation as to when the visual targets will be presented. No semantic anomalies were present in the filler sentences. Within each set, four discourses end in a relatively short segment of the discourse-final word, four in relatively long segments, and four in fully pronounced words. As in the first reaction-time experiment, the length of the short and long segments was defined as the mean length of the primes in the First and Actual Word bias test conditions, respectively. The practice material also varies the length of the discourses. There are four sets of eight discourses, either one, two, three, or four sentences long. The length of the discourse-final prime is varied over short, long, and full-word segments - as defined above - and this variation is evenly distributed over the discourses. Five practice discourses contain semantic anomalies (i.e., an anomaly with respect to the relationship between the discourse and the visually presented word), and five discourses end in a prime that matches the associated visual target. These anomalies and prime-target matches were included to confront the subjects during the practice session with all the manipulations that occur in the experimental session. The visual targets for the filler and practice discourses were selected from those used in the first reaction-time experiment, so with respect to the test targets this set is controlled for length, number of syllables, grammatical form, and word-frequency.

Speech recording and splicing

The material was recorded in one session in a sound-attenuated booth via a Revox B77 MK II taperecorder with a Sennheiser MD-421-N microphone onto an AGFA PER-368 audiotape. The speaker produced the Neutral and Constraining Contexts for each target-pair in immediate succession. The Neutral Context included the specific token for the Neutral Verb, the Constraining Context included the Anomalous Verb. The same female speaker was used as for the recording of the material of the first reaction-time experiment. Following the analog recording, the stimuli were digitized using a sampling frequency of 20kHz, and a band-pass filter range of 50Hz to 10kHz.

The various experimental discourses for each target-pair were constructed by cross-splicing the digitized speech, using the speech waveform editor of the Speech Laboratory of the Max Planck Institute for Psycholinguistics. First, the discourse-final words were deleted and replaced by the same acoustic tokens that were presented in the first reaction-time experiment. The recording of the final sentence in the Neutral Contexts served as the Neutral Verb manipulation in the Constraining Contexts. Likewise, the recording of the final sentence in the Constraining Contexts served as the Anomalous Verb manipulation in the Neutral Contexts. One of the realizations of the second sentences of the Neutral and Constraining Contexts was chosen as the acoustic token for both Contexts. The result of these cross-splicings is that between sentential contexts the Neutral and Anomalous Verb manipulations are realized via the same acoustic tokens, and that the input characteristics of the discourse-final acoustic primes are identical for all of the experimental manipulations. The cross-spliced material, therefore, precludes the possibility of ascribing any observed processing effects to systematic or spurious physical differences in the auditory stimulation.

Method

Experimental design

As was already mentioned, the sentential-semantic distinction between Neutral and Constraining Contexts had to be realized as a between-subjects factor because the number of remaining target-pairs is too low to permit a fully factorial design. Within each of the sentential manipulations the same three main factors are realized. The first is Verb Type, with two levels, namely Neutral and Anomalous. The second is Prime Length, with three levels, namely First bias, Actual Word bias, and Full word. The third is Target, with two levels, namely Actual Word and Competitor. To ensure that each subject only sees each target word once, a latin squares design was used, resulting in 12 experimental conditions within each sentential manipulation: 2 (Verb Type) X 3 (Prime Length) X 2 (Target). The full design then is a mixed between- and within-subjects design, with the sentential manipulation as the only between-subjects factor, and all the other variables as crossed factors within subjects. In effect, there are two experiments each for the Neutral versus Anomalous Verb comparison, one with Neutral Contexts, and one with Constraining Contexts.

The 24 target-pairs were rotated by conditions over the 12 experimental versions of each sentential context manipulation, with each version having two Actual Words and Competitors in each condition. Following the rotation, the order of conditions within versions was randomized. The same randomization was used in all versions. Each visual target word occurred only once in each version, and each subject saw an equal number of targets in each of the 12 experimental conditions. Following the rotation, 30 of the 36 filler discourses were pseudorandomly dispersed among the test items. The remaining six fillers were used as startup fillers at the beginning of the test session, to stabilize subject responses following the break after the practice session. The order of the 32 practice discourses was determined by means of a random-number generator.

Procedure

The procedure for both sentential context experiments is the same as in the first reaction-time experiment, with one exception. The secondary task of occasionally writing down the last word of a presented sentence was replaced by a recognition posttest. In the posttest the subjects were given a form with ten written discourses, five of which had actually been presented as fillers (with fully pronounced discourse-final words), and were requested to indicate which discourses they had heard during the experiment. The subjects were informed before the test session that a posttest would be administered, and were told that this was to check that they had actually been carefully attending to the auditory input.

One session, excluding instruction and posttest but including practice, lasted just under 15 minutes. This short testing period ensured that the subjects could maintain a high level of concentration throughout the experiment, without experiencing any undue mental fatigue.

Subjects
A total of 216 subjects was tested from the Max Planck Institute for Psycholinguistics student-subject pool, 108 subjects on each sentential-context experiment, 9 on each experimental version. None of these subjects had participated in the gating study, the first reaction-time experiment, or in any of the cloze tests. Subjects were paid Hfl 8.50 for their participation.

Results

Data analysis
Three subjects in different versions of the Neutral Context experiment, and two subjects in different versions of the Constraining Context experiment had to be rejected because of excessively long naming times (well over 800 msec). To facilitate the statistical analysis, the data for one subject were selected at random and deleted from each of the other versions of the experiments, resulting in a total of 96 subjects in each experiment, 8 per version. These subjects' performance on the recognition posttest showed, on average, 85% correct identification. The same procedure as in the first reaction-time experiment was used to replace extreme and zero values. The number of errors was negligible: 4 (0.17%) in the Neutral Context experiment, and 12 (0.52%) in the Constraining Context experiment. The number of extreme values was 90 (3.9%) and 68 (2.95%), respectively. In total then, some 4% of the latencies in the Neutral Context experiment were adjusted, and some 3.5% in the Constraining Context experiment.

Analysis of the Neutral Context results
Table 6 lists the mean naming times over subjects for the Anomalous and Neutral Verb environments, as a function of prime length. These numbers are also represented in Figure 3.

Table 6: Neutral Contexts, mean naming latencies for targets, by verb type and prime length.

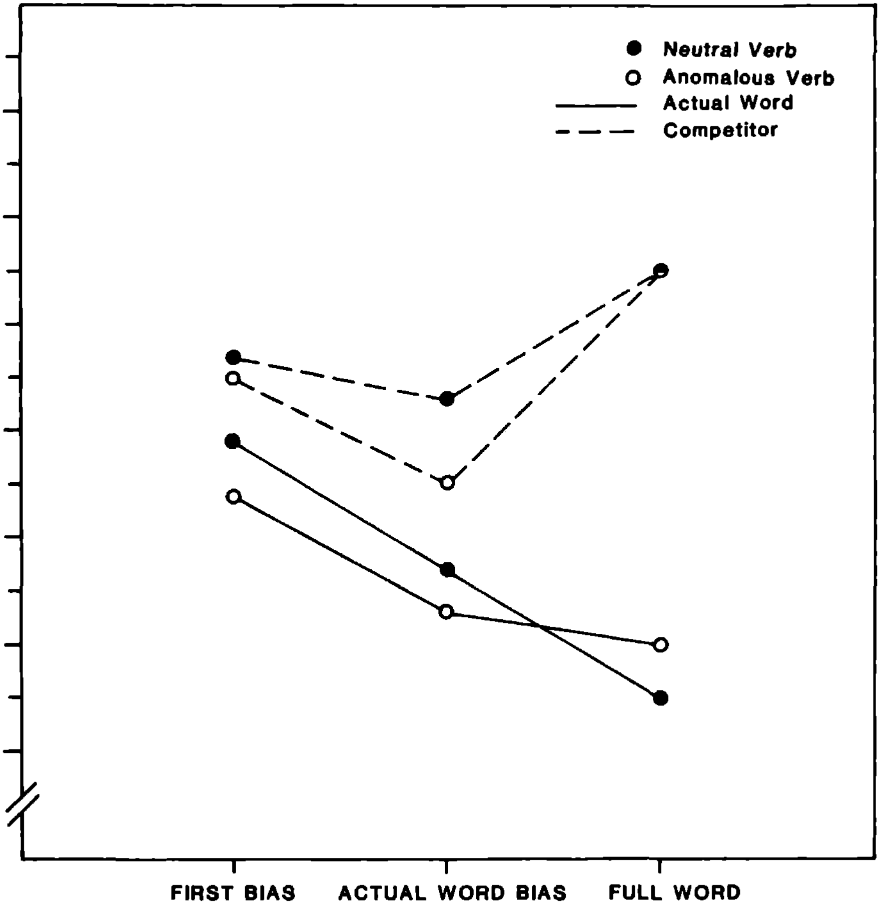
	Prime Length					
	First bias		AW – bias		Full word	
	Anom	Neut	Anom	Neut	Anom	Neut
Actual Word	384	389	373	377	370	365
Competitor	395	397	385	393	405	405

The subject analysis of variance shows a significant main effect of Target and Prime Length, as well as a significant interaction between these two factors. No other factors or interaction terms reach significance. The relevant statistics are as follows:

Target	$F_{1,95} = 115.24$	MSe=1031	$p<0.01$
Prime Length	$F_{2,190} = 6.14$	MSe=1401	$p<0.01$
Verb Type	$F_{1,95} = 1.12$	MSe=1214	$p=0.29$
Target X Prime Length	$F_{2,190} = 20.18$	MSe=1083	$p<0.01$
Target X Verb Type	$F_{1,95} < 1.00$	MSe=1890	$p=0.70$
Prime Length X Verb Type	$F_{2,190} = 1.35$	MSe=1286	$p=0.26$
Target X Prime Length X Verb Type	$F_{2,190} < 1.00$	MSe=2450	$p=0.88$

The significant main effect of Prime Length shows that the auditory stimulus information is affecting the ongoing processing. Its interaction with Target indicates that the Actual Words and Competitors are differentially affected by the amount of auditory stimulus information that has been processed before the targets are presented. Inspection of the individual reaction-times reveals that in close analogy to the response pattern obtained in the Carrier Phrase experiment, the latencies for the Actual Words decrease as a function of increases in the length of the prime. Separate analyses of variance reveal that in the Anomalous Verb environments, the 11 msec difference of the transition from the First bias to the Actual Word bias position is significant ($F_1(1,95)=5.43$, MSe=1149, $p=0.02$), but that the 3 msec difference of the transition from the Actual Word bias to the Full word position is not ($F_1(1,95)<1.00$, MSe=1294, $p=0.54$). In the Neutral Verb environments, the 12 msec transition effects from First bias to Actual Word bias, and from Actual

Figure 3: Mean naming latencies for Actual Words and Competitors in Neutral Contexts, as a function of verb type and prime length.



Word bias to Full word position, are significant (respectively: $F_1(1,95)=5.18$, $MSe=1310$, $p=0.02$; $F_1(1,95)=5.18$, $MSe=1288$, $p=0.02$). Combining the data for the Actual Words in the two levels of Verb Context results in a significant 12 msec difference going from the First to the Actual Word bias position ($F_1(1,95)=12.1$, $MSe=538$, $p<0.01$), and in a significant 8 msec difference going from the Actual Word bias to the Full word position ($F_1(1,95)=4.88$, $MSe=554$, $p=0.03$).

The latencies for the Competitors show an initial decrease going from the First bias to the Actual Word bias position, although this pattern is only clearly present in the Anomalous Verb condition. The 10 msec difference in the Anomalous Verb environment is marginally significant ($F_1(1,95)=3.60$, $MSe=1285$, $p=0.06$), but the 4 msec difference in the Neutral Verb environment is non-significant ($F_1(1,95)<1.00$, $MSe=1777$, $p=0.44$). Following Full word presentation, the Competitors show significantly longer latencies compared to the Actual Word bias position (Anomalous Verb environment: 20 msec, $F_1(1,95)=10.16$, $MSe=1913$, $p<0.01$; Neutral Verb environment: 12 msec, $F_1(1,95)=4.10$, $MSe=1752$, $p=0.05$). This is in accordance with the basic interference effect observed in the Carrier Phrase experiment.

In summary, the Neutral Contexts evoke basically the same processing profiles for the Actual Words and their Competitors as the Carrier Phrase experiment. For the Neutral Verb conditions this is exactly what was predicted, because these discourses were specifically constructed to contain no sentential- or lexical-semantic information that could potentially affect the on-line processing of the stimulus. Therefore, the ongoing processing in these discourses should closely approximate the processing in the carrier phrases, and it does.

The non-significant main effect of Verb Type, together with its non-significant interactions with the other factors indicates that despite the presence of a semantic anomaly concerning the Competitors in the Anomalous Verb environments, there is no effect of verb context on the ongoing processing. To better assess the specific effects of Verb Type and Prime Length on the targets, separate analyses of variance by Actual Word and Competitor were performed. The statistics for the Actual Word targets are:

Prime Length	$F_{2,190} = 15.32$	$MSe=1166$	$p<0.01$
Verb Type	$F_{1,95} < 1.00$	$MSe= 829$	$p=0.63$
Prime Length X Verb Type	$F_{2,190} < 1.00$	$MSe=1398$	$p=0.41$

The non-significant effect of Verb Type on the processing of the Actual Words fits with the predictions described previously. The distinction between Neutral and Anomalous Verbs only applies to the Competitor targets: with respect to the Actual Words both verb types are semantically neutral and non-anomalous environments. The non-significant result for the processing of the Actual Words following both Neutral and Anomalous Verbs, empirically verifies that the specific verbs used for the Verb Type manipulation do not, as such, elicit any differential processing effects.

The statistics for the Competitor targets are as follows:

Prime Length	$F_{2,190} = 9.56$	MSe=1318	$p<0.01$
Verb Type	$F_{1,95} < 1.00$	MSe=2276	$p=0.42$
Prime Length X Verb Type	$F_{2,190} < 1.00$	MSe=2339	$p=0.72$

Clearly, the Neutral and Anomalous Verbs are not differentially affecting the processing of the Competitors. The largest effect is 8 msec between the Anomalous and the Neutral Verbs at the Actual Word bias position. Not only is this effect not significant ($F_1(1,95)=1.41$, MSe=1926, $p=0.24$), but it is also in the wrong direction. The significant result for Prime Length indicates that differences in the auditory stimulus information do produce an overall processing effect, as was already apparent from the statistical comparisons reported above between the levels of the factor Prime Length. How do these results relate to the predictions made by the on-line processing models discussed in the previous section? I will first focus on the interactive models.

The results argue against both all-or-none and interactive-activation models. First, and most importantly, there is no significant increase in the latencies in the Anomalous Verb environments compared to the Neutral Verbs. This argues against both kinds of interactive processing models. Second, the significant effect of Prime Length shows that contrary to the prediction of the all-or-none models, the processing of the Competitors is affected by the available auditory stimulus information. Although in a separate analysis of variance on the Competitors in Neutral Verb environments, no overall effect of prime length emerges ($F_1(2,190)=1.86$, MSe=1961, $p=0.16$), the same analysis for the Anomalous Verb environments does show a significant overall effect of the length of the auditory prime ($F_1(2,190)=5.73$, MSe=1695, $p=0.004$), and this is further supported by the results reported above on the transition effects between the three levels of Prime Length. Taken together with the non-significant main and interaction effects of Verb Type in the overall analysis of variance, the results are clearly not in accordance with the predictions of the interactive models.

Turning to the autonomous processing models, the absence of a suppression effect between the Neutral and Anomalous Verb environments at the Actual Word bias position, runs counter to the claims made by those autonomous models which assume that the lexical selection process operates within a domain that contains lexical-semantic information. If such information were represented, then the Anomalous Verb should adversely affect the processing of the Competitor. Clearly this is not the case. If anything, the effect is in the opposite direction. The only model that predicts the observed pattern of results for the Competitor targets, is the kind of autonomous model proposed by Forster (1979). This model does not allow semantic information of any kind to affect the lexical selection process and, therefore, predicts that the results for the Competitors following Anomalous Verbs should be the same as following Neutral Verbs. This is basically the result that obtains. The only aspect of the data which does not fit well with Forster's autonomy model is the lack of a differential effect for the Competitors in the Neutral and Anomalous Verbs environments following the Full word prime. It is at this point that one would expect that in Forster's model the semantic constraints of the verbs should have an effect, but they do not.

Summarizing the results of the Neutral Context manipulation, the overall pattern of results closely fits the pattern obtained in the Carrier Phrase experiment. Differential activation is found for the Actual Word and Competitor targets as a function of the accumulating acoustic information. No processing effects obtain for the Neutral versus Anomalous Verb manipulation. These results are not predicted by interactive processing models. Autonomous processing models which assume a rich lexical-semantic processing domain also cannot adequately account for the data. Autonomy models which constrain the domain of lexical processing to (frequency-weighted) form-representations provide the most inclusive interpretation of the results.

Analysis of the Constraining Context results

Table 7 lists the mean naming times over subjects for the Anomalous and Neutral Verb environments, as a function of prime length. These numbers are also represented in Figure 4.

Table 7: Constraining Contexts, mean naming latencies for targets, by verb type and prime length.

	Prime Length					
	First bias		AW – bias		Full word	
	Anom	Neut	Anom	Neut	Anom	Neut
Actual Word	372	382	373	379	370	374
Competitor	394	385	394	393	405	401

The analysis of variance by subjects shows a significant main effect for the factor Target only, and significant interactions of Target with both Prime Length and Verb Type. The statistics are as follows:

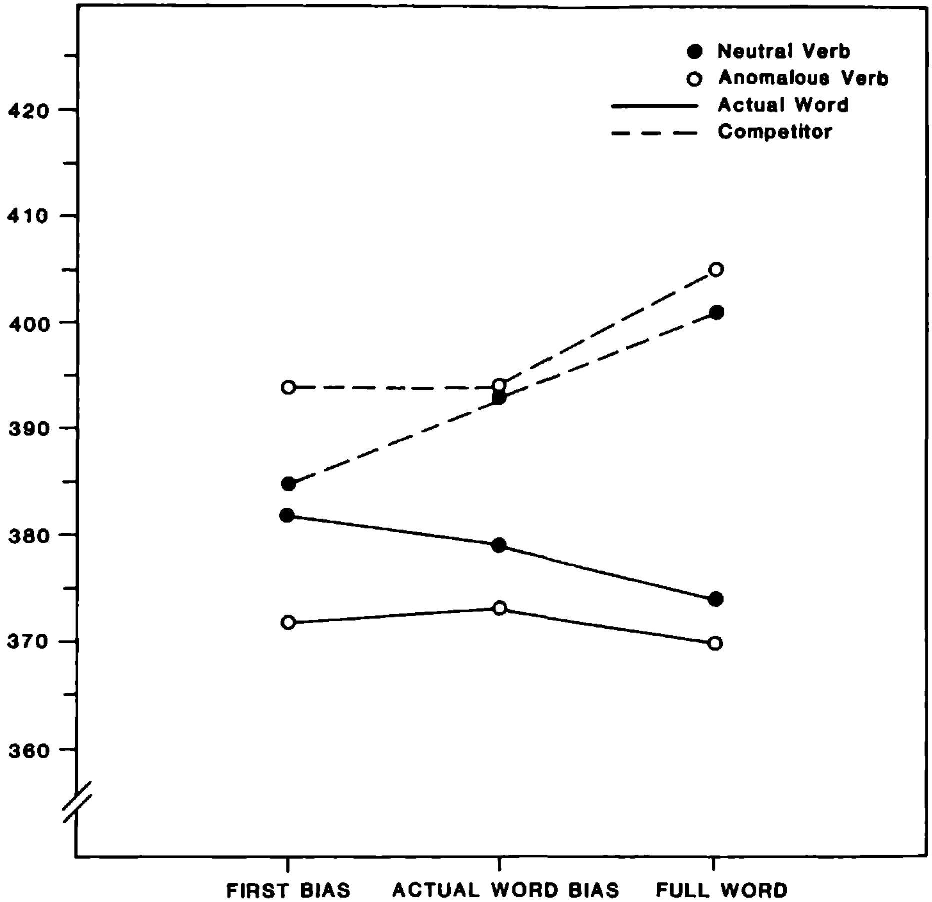
Target	$F_{1,95} = 95.75$	MSe=1241	$p<0.01$
Prime Length	$F_{2,190} < 1.00$	MSe=1685	$p=0.39$
Verb Type	$F_{1,95} < 1.00$	MSe=1179	$p=0.66$
Target X Prime Length	$F_{2,190} = 7.34$	MSe=1232	$p<0.01$
Target X Verb Type	$F_{1,95} = 4.11$	MSe=2302	$p=0.04$
Prime Length X Verb Type	$F_{2,190} < 1.00$	MSe=1080	$p=0.83$
Target X Prime Length X Verb Type	$F_{2,190} < 1.00$	MSe=2269	$p=0.60$

There is no overall effect of the factor Prime Length, but its significant interaction with Target indicates that the auditory stimulus information is differentially affecting the ongoing processing. To investigate this interaction effect in more detail, separate analyses of variance by Actual Word and by Competitor were performed. The statistics for the Actual Word targets are:

Prime Length	$F_{2,190} = 1.25$	MSe=1223	$p=0.29$
Verb Type	$F_{1,95} = 5.10$	MSe=1236	$p=0.03$
Prime Length X Verb Type	$F_{2,190} < 1.00$	MSe=1467	$p=0.73$

What this analysis reveals is that there is an effect of the Neutral versus the Anomalous Verb on the processing of the Actual Words, despite the fact that these two kinds of verbs do not differ in their semantic implications for the Actual Words, and despite the fact that in the Neutral Contexts these verb environments did not affect the processing of the Actual Words. Overall, the

Figure 4: Mean naming latencies for Actual Words and Competitors in Constraining Contexts, as a function of verb type and prime length.



target words are responded to some 6 msec faster when preceded by Anomalous than by Neutral Verbs. Closer inspection of the naming latencies shows that the largest effect of Verb Type is at the First bias position, where the difference in latency between the Anomalous and Neutral Verbs is 10 msec. This effect is significant ($F_1(1,95)=4.20$, MSe=1165, $p=0.04$). The 6 msec difference at the Actual Word bias position, and the 4 msec difference at the Full word position are not significant (respectively: $F_1(1,95)=1.06$, MSe=1439, $p=0.31$; $F_1(1,95)<1.00$, MSe=1566, $p=0.47$). Nevertheless, the differences between the three levels of the factor Prime Length are slight, as is demonstrated by the non-significant interaction term. In other words, the Actual Words show no processing effect due to increasing auditory stimulus information. This is different from the effects of Prime Length obtained in the Neutral Context experiment. There the latencies to the Actual Words decrease with increasing prime length. The present absence of an effect of Prime Length can be taken to be indicative of an early effect on the processing of the Actual Words of the restrictions conveyed by the sentential-semantic information of the Constraining Contexts. The possible statistical significance of this difference for the Actual Words between the Neutral and Constraining Contexts, and its implications for the validity of autonomous versus interactive processing models, will be addressed below in the results section on the combined analysis of Neutral and Constraining Contexts.

The statistics for the Competitor targets are as follows:

Prime Length	$F_{2,190}$	= 5.38	MSe=1693	$p<0.01$
Verb Type	$F_{1,95}$	= 1.52	MSe=2245	$p=0.22$
Prime Length X Verb Type	$F_{2,190}$	< 1.00	MSe=1882	$p=0.62$

The effect of Verb Type is not significant. This reveals that the significant Target by Verb Type interaction in the main analysis of variance is to be attributed solely to the processing effects of Verb Type for the Actual Words, and in particular to the significant effect at the First bias position. Whatever the origin of this effect may be, from the present analysis of variance results it is clear that - as was found for the Neutral Contexts - there is no differential effect of the Anomalous versus Neutral Verb manipulation on the processing of the Competitor targets. The largest difference of 9 msec at the First bias position does not reach significance ($F_1(1,95)=1.94$, MSe=2136, $p=0.17$). In contrast to the Actual Words, the Competitors are affected by the accumulating information of the auditory prime, but not to the same extent as in the Neutral Contexts. The basic pattern is the by now familiar result of increased latencies to the Competitors following Full word prime-lengths, in comparison to the Actual Word bias position. However, the only significant increase is the 11 msec difference between the Actual Word bias and the Full word position for the Anomalous Verb environments ($F_1(1,95)=3.77$, MSe=1685, p=0.05). These results are similar to those obtained in the Neutral Context experiment, and, therefore, they best fit an autonomous processing model of the kind proposed by Forster (1979).

In summary, the data for the Constraining Contexts provide no evidence in support of interactive processing models. The overall non-significant effect of Verb Type as well as its non-significant effect in the sub-analysis for Competitor targets, clearly contradicts the predictions made by the interactive models. As was the case in the Neutral Context, this lack of an effect of the factor Verb Type argues in favour of those autonomy models which assume basically only form-representations as active elements during the processes of lexical access and selection.

Analysis of the Neutral versus Constraining Context results
A combined analysis of variance on the Neutral and Constraining Contexts is particularly relevant with respect to the predictions made by interactive processing models. These models assign considerable weight to top-down influences of sentential-semantic information on the ongoing analysis of the incoming signal. Comparing the separate processing effects on the Actual Words and on the Competitors as a function of the two levels of the factor Sentential Context, provides a test of the fundamental processing nature that characterizes interactive models.

Combining the datasets of the Neutral and Constraining Contexts results in a mixed design for the analysis of variance. The factor Sentential Context entails a between-subject comparison, the other factors are all within-subject comparisons. So, subjects are nested within Sentential Context and crossed with the other factors. In all, there are 24 conditions: Sentential Context X Verb Type X Prime Length X Target = 2 X 2 X 3 X 2. Before computing the analysis of variance the data were first normalized for subject differences. For each subject the grand mean over all conditions was calculated, and this number was subtracted from each individual datapoint for that subject. In this way, spurious and irrelevant effects that arise from individual differences between subjects in their speed of response are eliminated between the two Sentential Context datasets. For convenience, positive numbers were created from the difference scores by adding the grand mean of the combined dataset to each of these scores. Note that for the main and interaction error terms of the factors in the analysis of variance - with the obvious exception of the between-subject main error term - this normalization procedure has no effect, since it involves a monotonic transformation of the data.[5] Normalized reaction-times are presented because they enable an easier comparison of the between-subject latency effects, in particular in pairwise comparisons. In fact, however, the numbers in Table 6 and 7 and in Table 8 reveal that the normalization procedure produces differences of maximally 1 msec compared to the non-normalized data. In other words, the variance due to subjects is extremely constant both within and between the datasets. Table 8 lists the mean normalized naming times over subjects for the Neutral and Constraining Contexts, as a function of Verb Type and Prime Length. These numbers are also represented in Figures 5a and 5b. Figure 5a contains the data for the Actual Words, and Figure 5b for the Competitors.

Table 8: Neutral and Constraining Contexts, mean normalized naming latencies for targets, by verb type and prime length.

	Neutral Context					
	First bias		AW – bias		Full word	
	Anom	Neut	Anom	Neut	Anom	Neut
Actual Word	384	388	372	376	369	365
Competitor	394	397	385	392	405	404
	Constraining Context					
	First bias		AW – bias		Full word	
	Anom	Neut	Anom	Neut	Anom	Neut
Actual Word	373	383	374	379	371	375
Competitor	395	386	395	394	406	401

The analysis of variance statistics are as follows:

Sentential Context	$F_{1,190} = 0.00$	MSe= 0	$p=1.00$
Target	$F_{1,190} = 209.26$	MSe=1136	$p<0.01$
Prime Length	$F_{2,380} = 2.50$	MSe=1543	$p=0.08$
Verb Type (VT)	$F_{1,190} = 1.12$	MSe=1197	$p=0.29$
Target X Prime Length	$F_{2,380} = 25.36$	MSe=1158	$p<0.01$

Figure 5a: Mean normalized naming latencies for Actual Words in Neutral and in Constraining Contexts, as a function of verb type and prime length.

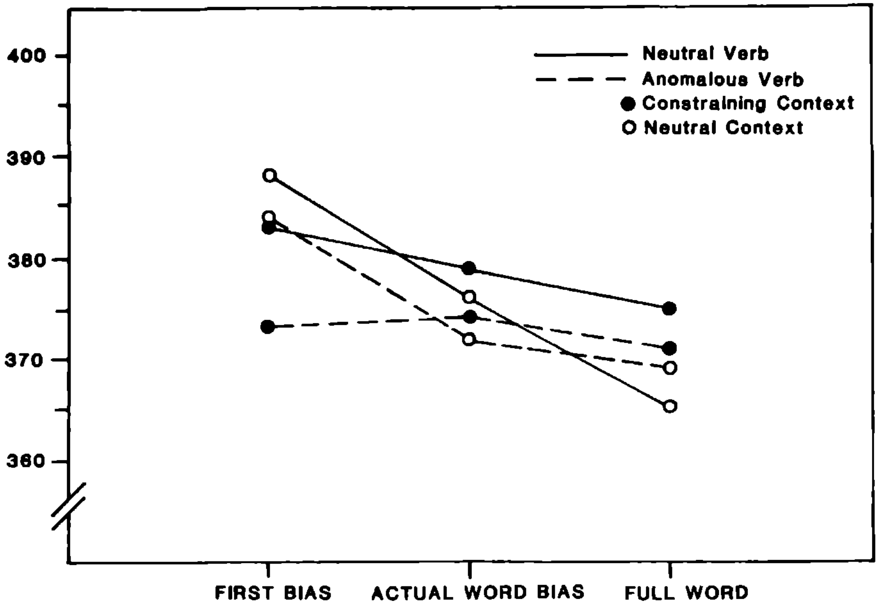
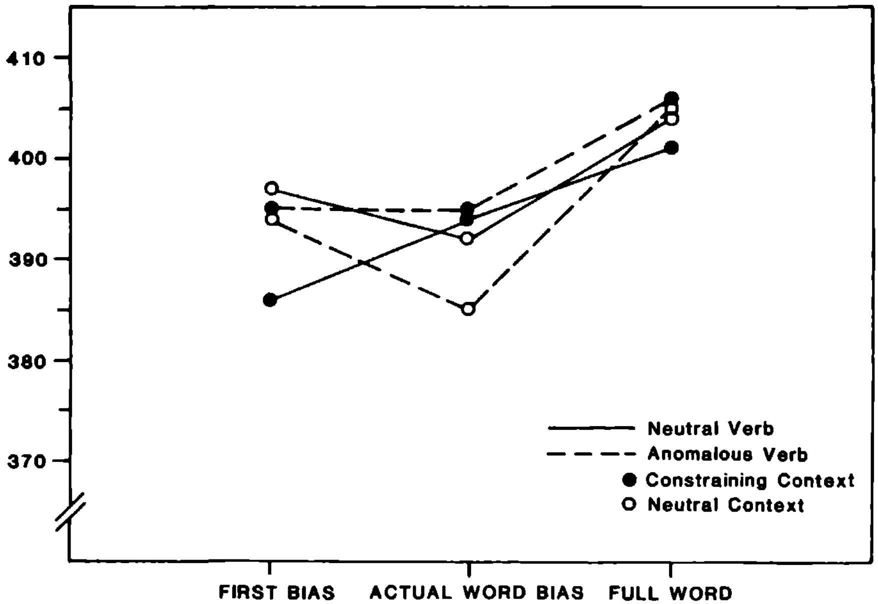


Figure 5b: Mean normalized naming latencies for Competitors in Neutral and in Constraining Contexts, as a function of verb type and prime length.



Target X Verb Type	$F_{1,190}$	= 1.51	MSe=2096	p=0.22
Prime Length X Verb Type	$F_{2,380}$	= 1.25	MSe=1183	p=0.29
Target X Prime Length X Verb Type	$F_{2,380}$	< 1.00	MSe=2359	p=0.58
Sentential Context (SC) X Target	$F_{1,190}$	< 1.00	MSe=1136	p=0.99
SC X Prime Length	$F_{2,380}$	= 4.10	MSe=1543	p=0.02
SC X Verb Type	$F_{1,190}$	< 1.00	MSe=1197	p=0.68
SC X Target X Prime Length	$F_{2,380}$	= 1.32	MSe=1158	p=0.27
SC X Target X Verb Type	$F_{1,190}$	= 3.13	MSe=2096	p=0.08
SC X Prime Length X Verb Type	$F_{2,380}$	< 1.00	MSe=1183	p=0.67
SC X Target X Prime Length X VT	$F_{2,380}$	< 1.00	MSe=2359	p=0.92

The significant main effect for Target and its interaction with Prime Length are not surprising given the results for the separate analyses of variance on the two sentential contexts. The same holds for the non-significant main and interaction effects due to Verb Type. What is mainly of interest here, are the effects with the factor Sentential Context. The non-significant Sentential Context by Target interaction indicates that there is no overall differential effect of sentential-semantic information on the processing of the Actual Words and their Competitors. This contrasts sharply with the fundamental processing claim of interactive models that such information can and will affect lexical processing. Similarly, the non-significant interaction of Sentential Context with Verb Type implies that the overall processing impact of Neutral and Anomalous Verbs is not differentially affected by the additional sentential-semantic information of the Constraining Contexts. This is again opposed to at least some of the claims made by interactive-activation models. To further decompose these effects, separate analyses of variance were computed for the Actual Words and for the Competitors. The statistics for the Actual Words are as follows:

Sentential Context (SC)	$F_{1,190}$	< 1.00	MSe= 568	p=0.88
Prime Length	$F_{2,380}$	= 12.23	MSe=1195	p<0.01
Verb Type	$F_{1,190}$	= 4.20	MSe=1032	p=0.04
SC X Prime Length	$F_{2,380}$	= 4.01	MSe=1195	p=0.02
SC X Verb Type	$F_{1,190}$	= 2.07	MSe=1032	p=0.15
SC X Prime Length X Verb Type	$F_{2,380}$	< 1.00	MSe=1433	p=0.80

The significant main effect of Verb Type arises from the effect of this factor in the Constraining Contexts. A possible - albeit somewhat strained - explanation here is that the two verb types do differ after all in their semantic implications for the Actual Words, but that these differences are so weak that they only emerge in combination with the constraints of the sentential-semantic information. This then would explain the 15 msec difference at the First bias position between the Constraining Contexts with Anomalous Verbs and the Neutral Contexts with Neutral Verbs. This 15 msec difference could under this description of the data be taken as evidence for an early processing effect on the Actual Words, and, therefore, as supporting evidence for interactive models.

The significant Sentential Context by Prime Length interaction reflects a differential effect already referred to in the discussion of the Constraining Context data. Namely, that in contrast to when presented in Neutral Contexts, the Actual Words in the Constraining Contexts show no effect of increasing prime length. In addition, the overall latencies for the Actual Words in the Constraining Contexts at the First bias position are 8 msec faster than in the Neutral Contexts. This could be indicative of an early effect of sentential-semantic information on the processing of the Actual Words. However, this overall difference collapses across Neutral and Anomalous Verb Types, and given that the separate analyses of variance showed that Verb Type does produce a significant main effect on the Actual Words in the Constraining Contexts, a potential early effect of sentential-semantic information has to be assessed via the means for Neutral and Anomalous Verbs separately. The 11 msec difference at the First bias position for Anomalous Verb environments is significant ($F_1(1,190)=5.06$, $MSe=1102$, $p=0.03$). This effect indicates an early processing effect of sentential-semantic information, and, therefore, provides support for interactive processing models. However, the difference is not sustained over the following two Prime Length positions, and the 5 msec effect in the Neutral Verb environments is not significant ($F_1(1,190)=1.18$, $MSe=1011$, $p=0.28$). Moreover the 10 msec difference at the Full word position for Neutral Verb environments is in the wrong direction, and attains significance ($F_1(1,190)=3.85$, $MSe=1293$, $p=0.05$). So, among all the relevant comparisons this datapoint is in accordance with the predictions of interactive processing models, but it is not supported by the results from the other comparisons. If anything, the results from the other comparisons converge in an opposite direction from that predicted by interactive models.

The statistics for the Competitors are as follows:

Sentential Context (SC)	$F_{1,190} < 1.00$	$MSe= 568$	$p=0.95$
Prime Length	$F_{2,380} = 12.37$	$MSe=1505$	$p<0.01$
Verb Type	$F_{1,190} < 1.00$	$MSe= 205$	$p=0.76$
SC X Prime Length	$F_{2,380} = 2.05$	$MSe=1505$	$p=0.13$
SC X Verb Type	$F_{1,190} = 2.06$	$MSe=2260$	$p=0.15$
SC X Prime Length X Verb Type	$F_{2,380} < 1.00$	$MSe=2110$	$p=0.85$

No significant effects with Sentential Context are obtained. The processing of the Competitors is not adversely affected by the additional sentential-semantic information of the Constraining Contexts, contrary to the claims made by interactive processing models. The marginally significant 11 msec difference in the Neutral Verb environments at the First bias position ($F_1(1,190)=3.42$, $MSe=1733$, $p=0.07$), is in the opposite direction to that predicted by interactive models. The corollary prediction by interactive models that the suppression effect of the Competitors in the Anomalous Verb environments will be increased for the Constraining as compared to the Neutral Contexts, does not obtain. The significant 10 msec difference in Anomalous Verb environments at the Actual Word bias position ($F_1(1,190)=3.74$, $MSe=1298$, $p=0.05$), could be taken as evidence for an additional effect of the Constraining Context. However, the fact that the latencies significantly decrease in the Neutral Contexts with Anomalous Verb environments going from the First bias to the Actual Word bias position, argues against this interpretation, as does the non-significant difference for the same transition in the Constraining Contexts.

Taken together, the full pattern of results contains basically no evidence for additional or differential effects due to the sentential-semantic difference between Neutral and Constraining Contexts. As such, they provide no support for the processing claims made by interactive models.

Discussion

The overall thrust of the separate analyses of variance for the Neutral and for the Constraining Contexts, as well as of the combined analysis, is in the direction of autonomous processing models. The fact that the data contain practically no support for interactive processing models provides a positive argument for the validity of autonomy models. The disadvantage here is that the supporting argument is based almost entirely on null-effects, i.e., on the absence of effects due to sentential-semantic and lexical-semantic information. Next to this problem of substantiating a model by null-effects, some aspects of the results from the comparison between Neutral and Constraining Contexts do not fit well with the processing claims made by autonomy models. For instance, considering the Actual Words, the significant difference at the First bias position in Anomalous Verb environments is not readily explainable. Similarly, the significant effect for Neutral Verb environments at the Full word position runs counter to the predictions of autonomy models. With respect to the Competitors, the predicted decrease in latencies going from the First bias to the Actual Word bias position is not observed for the Constraining Contexts, and only partially for the Neutral Contexts. Finally, the absence of an effect at the Full word position for the Anomalous compared to the Neutral Verb environments in both the Neutral and the Constraining Contexts is at odds with autonomy claims concerning post-lexical integration processes.

Next to specific issues raised by the results of the present research, the overall absence of an effect for the Verb Type manipulation is particularly surprising. Research reported in the literature on the effects of verb-contexts shows that aspects of a verb's argument-structure can affect the on-line processing of stimuli occurring in its immediate temporal vicinity (cf. Chodorow, 1979; Clifton, Frazier, & Connine, 1984; Marslen-Wilson et al., 1988; Mitchell, 1987; Mitchell & Holmes, 1985; Schustack et al., 1987; Shapiro, Zurif, & Grimshaw, 1987, 1989; Tanenhaus, Stowe, & Carlson, 1985; but see Cutler, 1983; Hakes, 1971; Rayner & Duffy, 1986). Admittedly, the relationship of this research to the current work is not direct. The large majority of the experiments was performed in the visual domain only, a variety of tasks other than naming was used, no partial primes were presented, and the main focus was on parsing as opposed to semantic processing. However, this diverse collection only serves to underscore how pervasive the effects of verb-context seem to be, which makes it all the more puzzling that the Neutral and Anomalous Verb manipulation had no measurable on-line processing effect in the Neutral and Constraining Context experiments.

An obvious solution to the puzzle is to state - as some autonomy models do - that processing effects due to verb-argument structure are post-lexical effects which only exert their influence following completion of the lexical access and selection processes. That is, with respect to the Actual Words and the Competitors in the present experiments, the implications of verb-context are only operative at the level of lexical integration, and this level is taken to be functional after the preceding access and selection processes have produced their output. The corollary to this claim is that the paradigm and task employed in the present research (i.e., cross-modal candidate priming and naming) are sufficiently sensitive to tap into at least the on-line lexical selection process, and, moreover, that given the particular independent variables of the experiments, processes of lexical integration are not being measured. This position, then, assigns primacy to the full analysis of the auditory stimulus information and assumes that it is only following this analysis of the incoming signal - i.e., beyond the Full word position - that other sources of information, in casu the semantic information associated with the verb, can come into play and affect the ease with which the recognized word is integrated into the discourse representation of the preceding context. What this boils down to, is the basic claim that the experiments reported so far have been measuring too early in the ongoing comprehension process to pick up on any effects caused by verb-context. I will refer to this position as the post-lexical hypothesis.

There is a different solution to the puzzle of absent verb-context effects, and that is to say that there is a problem concerning the temporal relationship between the processing of the auditory stimulus information and the moment in time at which the subjects are required to generate an overt response. It can be claimed that the exact moment in time at which the visual target is presented is too early to allow the effect of the relevant lexical-semantic information to manifest itself in the obtained response times. In the experiments reported up till now, the visual target immediately followed the offset of the acoustic stimulation. That is, the inter-stimulus interval between the offset of the acoustic prime and the onset of the visual target was zero msec. In this situation, the auditory stimulus information as such might have been sufficient to engage on-line processes which are susceptible to lexical-semantic information, but these processes are tapped into at a moment in time at which the impact of this information is insufficiently developed to manifest itself in the subjects' performance. I will refer to this position as the time-constraint hypothesis.

We are faced then with two hypotheses concerning different aspects of the time-course of the ongoing comprehension process. On the one hand the post-lexical hypothesis which claims that the lexical access and selection processes linked to the eliciting auditory events - i.e., the three levels of the variable Prime Length - functionally precede the processing impact of verb contexts, and that therefore this impact is not being picked up given the specific independent variables of the experiments. On the other hand the time-constraint hypothesis which claims that in principle the lexical-semantic information of the verb will affect the ongoing stimulus analysis process - certainly at the level of the lexical selection process - but that due to insufficient available processing time in the experiments performed so far, this information has not yet exerted a measurable effect.

To investigate these hypotheses the following experiment uses an approach which has a long tradition in on-line psycholinguistic processing research. This is to manipulate the amount of processing time subjects have available following stimulation, before a response is required. Manipulating processing time has been extensively used and examined in the priming literature, in particular in research on semantic priming between visually presented prime-target wordpairs. The time intervening between prime and target is referred to, depending on the manner in which it is realized, as either Stimulus Onset Asynchrony (SOA) or Inter-Stimulus Interval (ISI). The overall finding is that with an increase in the amount of processing time available following the presentation of the prime and preceding the presentation of the target, the size of the semantic priming effect for the target increases. The time-range involved here is, on average, 100 to 2000 msec. The effects have been observed using both lexical decision and naming tasks, in combination with semantic priming, but also with repetition priming paradigms (see, for example, de Groot, 1984; de Groot, Thomassen, & Hudson, 1986; Feustel, Shiffrin, & Salasoo, 1983; Monsell, 1985; Neely, 1990; Scarborough, Cortese,

& Scarborough, 1977). The following experiment capitalizes on the perseveration of priming effects over relatively long stretches of time. The procedure is to keep the amount of stimulus information that has been analyzed constant, whilst at the same time increasing the amount of time available with which to process that information. Not only does this additional time enable more extensive processing of the auditory stimulus information, but it also, in principle, provides time for an interaction to emerge between the lexical-semantic information of the target-preceding verb and the semantic information of the set of potential word candidates activated on the basis of the stimulus information.

The two hypotheses outlined above make different predictions with respect to the effect of additional processing time on the possible impact of verb-contexts in the Neutral Context environments. The post-lexical hypothesis predicts effects of verb type (i.e., Anomalous versus Neutral Verbs) following the Full word position only, and then only for the word which has been selected on the basis of the fully analyzed input, i.e., the Actual Word. However, given that in the current experimental discourses both verb types are semantically neutral with respect to the Actual Words, and given that the discourses contain no specifically constraining information, no processing differences are expected to occur. Basically, the informational value of the target-preceding material is so low that no additional effects due to post-lexical integration can obtain. This, then, is one of those rare occasions in which a null-effect is actually predicted, as opposed to just found.

The time-constraint hypothesis predicts effects at prime positions before the Full word position. If it is the case that the Verb Type manipulation does not emerge in the observed latencies because the processing time available is insufficient, then an increase in the amount of time before a response is required from the subjects should be effective in bringing to the fore the otherwise submerged processing consequences of lexical-semantic information. Therefore, an effect of verb type on the Competitor targets is predicted to occur at certainly the Actual Word bias position. Here, it is expected that the latencies for the Competitors following Anomalous Verbs will be significantly longer than the latencies following Neutral Verbs.

Neutral and anomalous verb-contexts: Effects of processing time

Stimuli

The same stimuli were used as for the Neutral Context experiment. Given that the focus of this experiment is on the Verb Type environments, it was decided not to include the material of the Constraining Context experiment. The discourses comprising the Neutral Contexts do not contain constraining sentential-semantic information, so that any local processing effects caused by the Neutral and Anomalous Verbs can be observed without contamination from other sources.

Experimental design

The same basic design as used for the Neutral Context experiment is also employed here. So, there are 12 experimental conditions: 2 (Verb Type) X 3 (Prime Length) X 2 (Target). The additional variable of processing time is realized by two levels of the factor ISI, namely 100 msec and 500 msec. This factor is realized as a nesting dimension for items. Half of the 24 test target-pairs were randomly selected and assigned to the ISI=100 msec condition, the other half to the ISI=500 msec condition. The two levels of ISI were evenly distributed over the filler and practice items.

Procedure

The procedure is identical to that used in the Neutral Context experiment.

Subjects

A total of 108 subjects was tested from the Max Planck Institute for Psycholinguistics student-subject pool, 9 on each experimental version. None of these subjects had participated in any of the previously reported research. Subjects were paid Hfl. 8.50 for their participation.

Results

Data analysis

Two subjects in different versions of the experiment had to be rejected because of excessively long overall latencies (800 msec or more). To facilitate the statistical analysis, the date for one subject were selected at random and deleted from each of the other versions, resulting in a total of 96 subjects, 8 per version. Extreme values (N=111, 4.8%) and errors (N=5, 0.22%) were replaced using the standard procedure.

Analysis of variance

Given that the ISI manipulation is realized as a between-item variable, an item analysis of variance was performed, with items nested under the factor ISI and under the factor Target, and with 8 subjects in each cell of the replication dimension. Table 9 lists the mean naming times over subjects by Verb Type, as a function of Prime Length and ISI. The ISI=100 numbers are also represented in Figure 6a. The ISI=500 numbers are represented in Figure 6b.

Table 9: Neutral Contexts, mean naming latencies for targets, by verb type and ISI.

	ISI = 100 msec					
	Prime Length					
	First bias		AW – bias		Full word	
	Anom	Neut	Anom	Neut	Anom	Neut
Actual Word	406	403	392	395	394	391
Competitor	420	425	423	418	432	432
	ISI = 500 msec					
	Prime Length					
	First bias		AW – bias		Full word	
	Anom	Neut	Anom	Neut	Anom	Neut
Actual Word	366	363	366	368	374	389
Competitor	371	373	383	379	401	405

The analysis of variance shows significant main effects for the factors ISI, Prime Length, and Target, as well as significant first-order interactions for ISI X Target, and Target X Prime Length. The factor Verb Type does not obtain a significant main effect, nor does it enter into any significant interaction with the other factors. The relevant statistics are:

Inter-Stimulus Interval (ISI)	$F_{1,44} = 19.97$	MSe=3884	$p<0.01$
Target	$F_{1,44} = 8.43$	MSe=3884	$p<0.01$
Prime Length	$F_{2,88} = 8.48$	MSe= 509	$p<0.01$
Verb Type (VT)	$F_{1,44} < 1.00$	MSe= 338	$p=0.61$

Figure 6a: Mean naming latencies for Actual Words and Competitors in Neutral Contexts, as a function of verb type and prime length, ISI=100 msec.

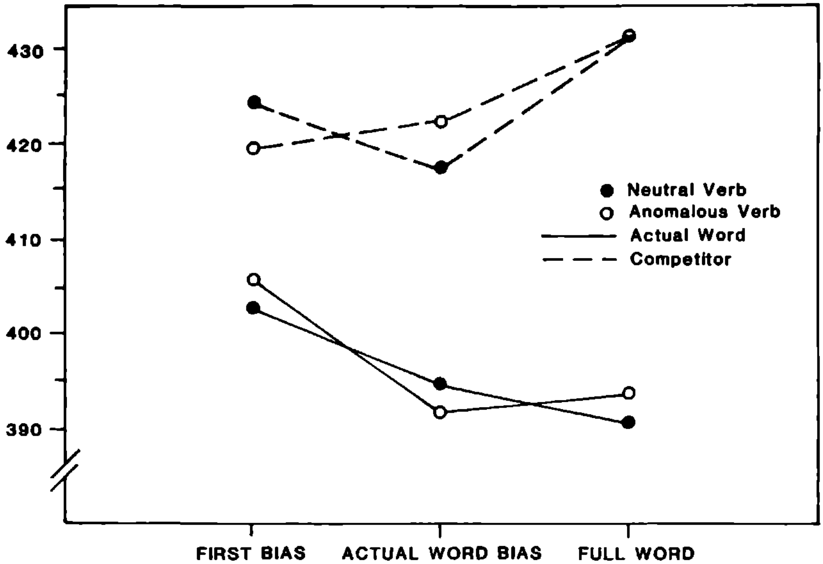
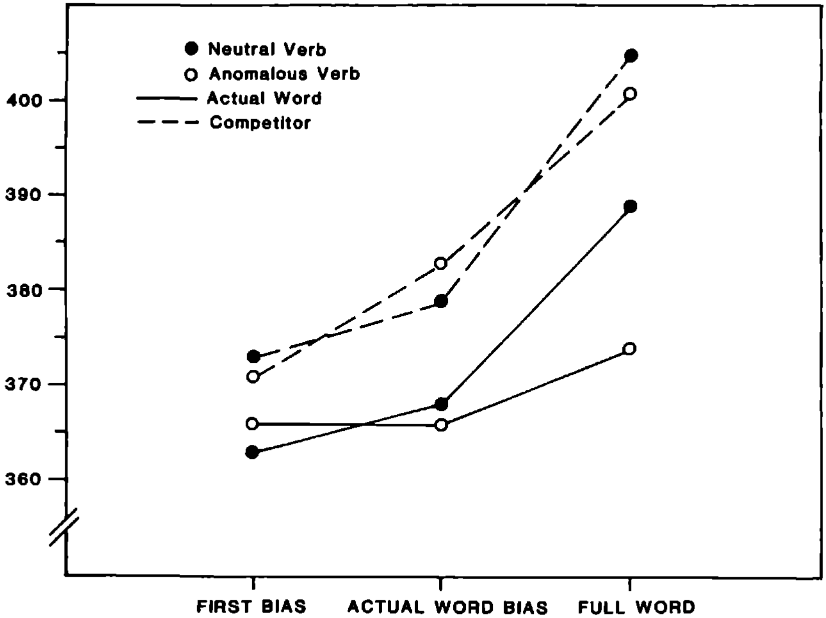


Figure 6b: Mean naming latencies for Actual Words and Competitors in Neutral Contexts, as a function of verb type and prime length, ISI=500 msec.



Target X Prime Length	$F_{2,88}$	=	3.62	MSe= 509	p<0.03
Target X Verb Type	$F_{1,44}$	<	1.00	MSe= 338	p=0.80
Prime Length X Verb Type	$F_{2,88}$	<	1.00	MSe= 333	p=0.63
Target X Prime Length X Verb Type	$F_{2,88}$	=	1.04	MSe= 333	p=0.36
ISI X Target	$F_{1,44}$	<	1.00	MSe=3884	p=0.35
ISI X Prime Length	$F_{2,88}$	=	7.55	MSe= 509	p<0.01
ISI X Verb Type	$F_{1,44}$	<	1.00	MSe= 338	p=0.48
ISI X Target X Prime Length	$F_{2,88}$	<	1.00	MSe= 509	p=0.87
ISI X Target X Verb Type	$F_{1,44}$	<	1.00	MSe= 338	p=0.53
ISI X Prime Length X Verb Type	$F_{2,88}$	<	1.00	MSe= 333	p=0.39
ISI X Target X Prime Length X VT	$F_{2,88}$	<	1.00	MSe= 333	p=0.76

The main effect for ISI reflects the difference in the overall speed of response for the 100 and 500 msec intervals. The grand mean for ISI=100 is 411 msec, whereas for ISI=500 it is 378 msec. Giving the subjects more time following the auditory presentation before an overt response is required, would seem to in general enhance their performance on the visual targets. Such an overall processing enhancement fits well with the general effects reported in the priming literature for manipulations of SOA and ISI within the 0-500 msec time-range. However, given that the ISI manipulation was realized as a between-item variable, the observed main ISI-effect could also be simply due to differences in the overall speed of processing between the item-sets of the two ISI-conditions. This experiment was performed to further investigate some hypotheses concerning the absence of effects due to verb type. Therefore, possible overall ISI-effects are as such not of any real interest or importance. However, as an aside it is interesting to assess whether the observed processing enhancement for ISI=500 compared to ISI=100 can indeed be ascribed fully to the additional 400 msec of available processing time in the ISI=500 condition. Therefore, the two sets of items that were used in the ISI=100 and the ISI=500 condition were separately analyzed in an item analysis of variance on the data of the first Neutral Context experiment, where these items had been presented with an ISI of zero msec. This analysis reveals that despite having been randomly selected for insertion in either the ISI=100 or the ISI=500 condition, the items of the ISI=500 set show an overall faster response time of 20 msec in comparison with the ISI=100 set, and this difference is significant ($F_2(1,44)=7.24$, MSe=3862, p=0.01). So, the observed ISI-effect is at least in part attributable to item-differences.[6]

Focussing on the effects of Prime Length, the significant interaction with ISI once again demonstrates that the cross-modal candidate priming paradigm in combination with a naming task is sufficiently sensitive to pick up on differential on-line processing effects. The pattern of results for the Actual Words in the ISI=100 condition is reminiscent of the preceding Neutral Context experiment. The latencies decrease going from the First bias to the

Actual Word bias position. The 8 msec difference for the Neutral Verb environments is not significant, and the 14 msec difference for the Anomalous Verb environments is marginal ($F_2(1,11)=3.70$, $MSe=318$, $p=0.08$). Similarly, the pattern for the Competitor targets in the Neutral Verb environments approximates the results of the previous Neutral Context experiment. There is an indication of a decrease in latencies going from the First bias to the Actual Word bias position, but as in the first Neutral Context experiment this effect is not significant. The transition from Actual Word bias to Full word position results in a 14 msec increase in latencies, but this is not significant ($F_2(1,11)=2.56$, $MSe=412$, $p=0.14$). For the Anomalous Verb environments - in contrast to the other Neutral Context experiment - there is no significant decrease going from the First bias to the Actual Word bias position (in fact, the 3 msec difference is in the opposite direction), and although there is a 9 msec increase in latencies between the Actual Word bias and the Full word position, this increase does not reach significance. So, although the pattern of results for the Competitor targets in the ISI=100 condition resembles the pattern observed earlier for Neutral Contexts (and certainly does not show a strikingly different profile), a clear interference effect is not found.

For the ISI=500 condition somewhat different results obtain. The Actual Words no longer exhibit a transition effect going from the First bias to the Actual Word bias position. The means for the Neutral and Anomalous Verb environments at the two prime positions do not differ. Similarly there is no significant transition effect in the Anomalous Verb environments going from the Actual Word bias to the Full word position. However, there is a 21 msec significant transition effect between these two positions in the Neutral Verb environments ($F_2(1,11)=5.71$, $MSe=459$, $p=0.04$). I have no explanation for this effect. One might argue that it points towards some hitherto undiscovered difference between the Neutral and Anomalous Verb environments with respect to the Actual Words. However, there is not even a hint of such a difference in any of the other Verb Type comparisons in the current experiment, and the Verb Type effects reported in the previous experiments also do not provide any clear support for a differential effect of the two kinds of verbs on the processing of the Actual Words. So, the increased latency for Actual Words in Neutral Verb environments at the Full word position remains a mystery. The increase does not seem systematic, since an analysis on these items in the first Neutral Context experiment shows a 10 msec decrease in the averaged latencies for the Neutral Verbs compared to the Anomalous Verbs.

The results for the Competitors in the ISI=500 condition no longer show any decrease in latencies for the transition between the First bias and the Actual Word bias position. However, both the 6 msec increase in the Neutral Verb environments and the 12 msec increase in the Anomalous Verb environments do not reach significance. What does emerge, is an interference effect going from the Actual Word bias to the Full word position. The 18 msec increase in the Anomalous Verb environment is only marginal ($F_2(1,11)=3.40$, $MSe=554$, $p=0.09$), but the 26 msec increase in the Neutral Verb environments is significant ($F_2(1,11)=14.79$, $MSe=287$, $p<0.01$).

There is an almost total lack of an effect of Verb Type. The only maverick datapoint here is the difference for Actual Words in the Full word position between Neutral and Anomalous Verb environments in the ISI=500 condition. This difference of 15 msec is only marginally significant ($F_2(1,11)=4.08$, $MSe=331$, $p=0.07$) and, as was already indicated above, cannot be satisfactorily explained. All other within-position and within-ISI comparisons of Neutral versus Anomalous Verbs environments for the Actual Words and for the Competitors do not reach significance. Clearly then, manipulating the amount of available processing time does not enable the lexical-semantic distinction between Neutral and Anomalous Verbs to emerge in the observed processing profile. This demonstrates that the overall absence of an effect of Verb Type in the previous Neutral and Constraining Context experiments is not being caused by tapping into the ongoing process at too early moments in time. In conclusion, the post-lexical hypothesis is not at odds with the present data (I am being cautious here because predicted null-effects are not the firmest basis for scientific confirmation), and the time-constraint hypothesis can be rejected.

Discussion

The ISI-experiment does not solve the puzzle of the absence of a processing effect due to verb-context. The results that have been reported so far not only exclude insufficient available processing time as the cause of the null-effect, but also negate claims that the experimental paradigm and task are insufficiently sensitive to tap into on-line lexical processes. The final remaining possible cause, therefore, resides in the stimulation itself. By this I do not mean the lexical characteristics of the target words: their similarity has been discussed previously, and has been empirically validated by the obtained reaction-time data. However, what might be causing the observed null-effects is the nature of the relationship between the auditory and the visual linguistic information.

In the material used in the preceding experimental programme, there have been no linguistic irregularities at the level of the auditory input. In all cases, the stimuli are natural and acceptable instances of spoken language. The reasoning here is that given that the basic phenomenon under investigation is the processing of spoken language, it is best to disturb this primary process as little as possible. Therefore, the semantic anomalies associated with the

Anomalous Verbs were always instantiated in relation to the Competitor target, i.e., the word that is not realized acoustically. In doing so, continued smooth processing at the level of the primary input is ensured. This means that any differential processing caused by the variable Verb Type, can only be assessed at the level of the visual Competitor targets. It is entirely possible that it is exactly because it has been attempted to assess the influence of verb-context in such an indirect manner, that no effects of verb-context have been observed. The presumed consequences for the activational state of the Competitors of the semantic information associated with the Anomalous Verbs were tapped into via the response times to these visually presented targets. Maybe this link is too indirect. Given that the primary comprehension process runs off in a normal and undisturbed manner, the effects of verb-context might be too subtle - certainly in the case of partial priming conditions - to bring about measurable processing consequences at the level of the visual targets. In this respect it is worth mentioning that practically all the studies on verb-context mentioned above have used only one modality for their investigations, and have observed quite strong effects.[7] Therefore, in a last attempt to demonstrate verb-context effects during on-line spoken-word processing, Neutral and Constraining Context experiments were run in which the Anomalous Verb manipulation was changed. New verbs which create a semantic anomaly in combination with both the Actual Words and the Competitors were inserted in both sentential contexts. Now, the listener is confronted with a semantically inappropriate utterance. If the verb-context information is picked up and used on-line during the processing of the incoming sentence, then this stimulus situation should result in clear negative processing consequences at the level of the Actual Words.

Neutral and anomalous verb-contexts: Disrupting the auditory process

Stimuli

The same basic stimulus set was used as for the first Neutral and Constraining Context experiments. The only difference is in the Anomalous Verbs. These are now new verbs which create a semantic anomaly in combination with both the Actual Word and the Competitor targets. At the same time, the sentences up to and including the pre-target verb are semantically appropriate discourses, and following the pre-target verb a natural continuation of the discourse is always possible. In other words, the semantic anomaly occurs only at the level of the Actual Word and the Competitor. The following is an example from the material for the Neutral Contexts:

Iedereen was zeer gemotiveerd om er het beste van te maken.
De mannen waren de hele dag druk bezig.
Een van hen kalmeert een b / ba / bad. Target: BAD / BAL

Three judges independently assessed that these criteria were indeed met in the material. As in the previous experiments, the same Anomalous Verbs were used in both the Neutral and the Constraining Contexts. The stimuli are listed in Appendix 3.

Recording
The Anomalous Verbs were recorded in the Neutral Context sentences, using the same recording procedure as in the previous research. Following digitization, the Actual Words of the new recording were replaced by their original recordings by means of cross-splicing. The cross-spliced final sentence was used to replace the discourse-final sentences used in the Anomalous Verb conditions of the first Neutral and Constraining Context experiments.

Experimental design and procedure
The experimental design and procedure is identical to that used in the first Neutral and Constraining Context experiments.

Subjects
A total of 216 subjects was tested from the Max Planck Institute for Psycholinguistics student-subject pool, 9 on each of the 12 experimental versions of the two context experiments. None of these subjects had participated in any of the previously reported research. Subjects were paid Hfl. 8.50 for their participation.

Results

Data analysis
Three subjects in different versions of the Neutral Context experiment, and two subjects in different versions of the Constraining Context experiment had to be rejected because of overly long naming times. For the statistical analysis the data of one subject were selected at random and deleted from each of the other remaining versions, resulting in a total of 192 subjects, 96 on each experiment, 8 per version. The standard update procedure was used. In the Neutral Context experiment there was a total of 94 replaced values (4.1%): 35 errors (1.5%) and 59 outliers (2.6%). In the Constraining Context experiment 97 values were replaced (4.2%): 29 errors (1.2%) and 68 outliers (3.0%).

Analysis of the Neutral Context results
Table 10 lists the mean naming times over subjects for the Anomalous and Neutral Verb environments, as a function of prime length. These numbers are also represented in Figure 7.

Table 10: Neutral Contexts, mean naming latencies for targets, by verb type and prime length.

	Prime Length					
	First bias		AW – bias		Full word	
	Anom	Neut	Anom	Neut	Anom	Neut
Actual Word	403	409	400	392	385	378
Competitor	406	410	403	412	412	416

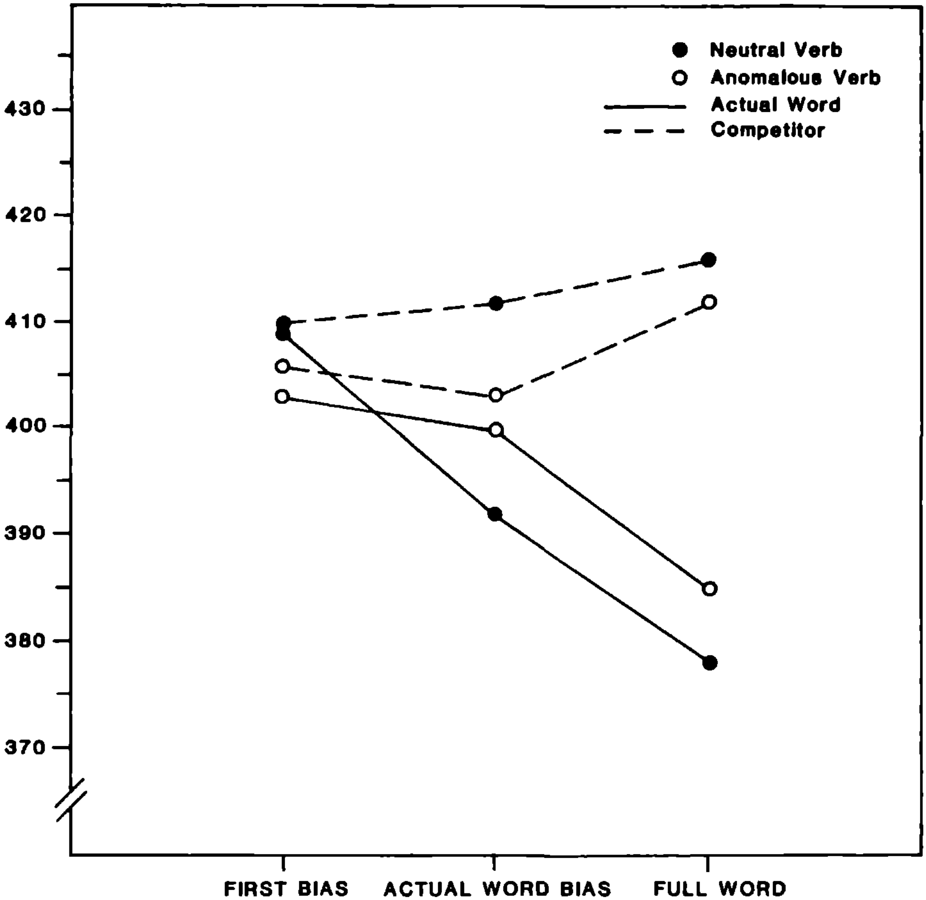
The subject analysis of variance shows significant main effects for the factors Target and Prime Length, as well as a significant interaction between the two. No other main or interaction terms reach significance. The relevant statistics are as follows:

Target	$F_{1,95} = 54.26$	MSe=1260	p<0.01
Prime Length	$F_{2,190} = 5.04$	MSe=1727	p<0.01
Verb Type	$F_{1,95} < 1.00$	MSe=1837	p=0.54
Target X Prime Length	$F_{2,190} = 14.51$	MSe=1618	p<0.01
Target X Verb Type	$F_{1,95} = 2.28$	MSe=2543	p=0.13
Prime Length X Verb Type	$F_{2,190} < 1.00$	MSe=1608	p=0.48
Target X Prime Length X Verb Type	$F_{2,190} < 1.00$	MSe=2597	p=0.47

Once again, no effect of the factor Verb Type is obtained. In separate analyses of variance by Actual Words and by Competitors this null-effect for Anomalous versus Neutral Verbs is maintained (Actual Words: $F_1(1,95)<1.00$, MSe=1766, p=0.40; Competitors: $F_1(1,95)=1.99$, MSe=2614, p=0.16). Furthermore, for both the Actual Words and the Competitors, none of the within prime length comparisons between the Anomalous and Neutral Verb environments reaches significance. The largest effect is the 9 msec difference for Competitor targets between the Anomalous and Neutral Verb environments at the Actual Word bias position, and this difference is still far from significant ($F_1(1,95)=2.02$, MSe=2091, p=0.16). Moreover, it is in the wrong direction. Clearly then, the overall results provide no evidence for a processing effect due to verb context.

Focussing on the transition effects, the Competitors show no differential

Figure 7: Mean naming latencies for Actual Words and Competitors in Neutral Contexts, as a function of verb type and prime length.



effects due to prime length. There is an indication of an interference effect in the Anomalous Verb environments going from the Actual Word bias to the Full word position, but this 9 msec difference is not significant ($F_1(1,95)=2.05$, $MSe=1905$, $p=0.16$). All other transition effects have F-values of less than 1. This absence of effects due to prime length contrasts with the significant transitions observed in the first Neutral Context experiment. Although there too the transition between the first two positions in the Neutral Verb environments did not reach significance, the other transitions did. In particular, interference effects were obtained at the Full word position compared to the Actual Word bias position. The present lack of interference effects for Competitor targets was also found in the Neutral Context ISI-experiment for the ISI=100 condition, in contrast to the ISI=500 condition which did show interference. In general, then, the manipulations of prime length produce a consistent overall processing profile with respect to the Competitor targets, but it appears that the effects are fragile, fluctuating on the borderline of statistical significance.

For the Actual Words, significant effects of stimulus information are obtained. In the Neutral Verb environments, the 17 msec transition effect from the First bias to the Actual Word bias position is significant, as is the 14 msec effect going from the Actual Word bias to the Full word position (respectively: $F_1(1,95)=10.50$, $MSe=1333$, $p<0.01$; $F_1(1,95)=4.85$, $MSe=1980$, $p=0.03$). In the Anomalous Verb environments, the 3 msec difference between the first two positions is not significant ($F<1.00$), but the 15 msec difference between the Actual Word bias and the Full word position is ($F_1(1,95)=6.21$, $MSe=1633$, $p=0.01$). In this pattern of results lies the only effect that can be interpreted as a differential influence of Verb Type. The fact that there is a significant transition effect for the Actual Words in the Neutral Verb environments going from the First bias to the Actual Word bias position, together with the fact that such a transition effect is not observed in the Anomalous Verb environments, could be taken as evidence for a negative influence of the Anomalous Verb. That is, the semantic information associated with the Anomalous Verb results in a suppression of the activational level of the Actual Word, effectively marking it as inappropriate given the preceding context. Therefore, the Actual Words in these verb environments no longer benefit from the increasing stimulus information, and this is reflected in the non-significant transition effect. In the Neutral Verb environments the Actual Words are appropriate candidates, and, therefore, in this stimulus situation they do receive increasing activation as a function of the accumulating acoustic information. The fact that the Actual Words do not differ at the First bias position between the Anomalous and Neutral Verb environments would then indicate that the processing effects of verb context are not operative at this earlier moment in the ongoing stimulus analysis process. This activational interpretation is supported by the results found in the first Neutral Context experiment reported in this chapter. Significant transition effects between the first two prime positions were obtained for the Actual Words in both the Neutral and the Anomalous Verb environments. In this first experiment, the semantic clash with the Anomalous Verb only occurred at the level of the Competitor targets: the Actual Words were always appropriate completions.

What argues against this analysis of the observed transition effects is the fact that in both verb environments the difference for the Actual Words between the Actual Word bias position and the Full word position is equally large, and significant (Anomalous Verb environments: 15 msec, Neutral Verb environments: 14 msec; the F-values were reported above). To some extent this counter-argument can be put aside by referring to the basic stimulus uncertainty effect that was reported earlier in this dissertation: latencies following partial primes tend to be overall slower than latencies following full primes. However, this leaves unexplained why the size of the transition effect is equal: one would expect the Verb Type manipulation to interact with Prime Length for the Actual Word bias and the Full word positions, but it clearly does not ($F_1(1,95)=2.58$, MSe=1614, $p=0.11$). Moreover, the 8 msec difference between Anomalous and Neutral Verbs at the Actual Word bias position is not significant ($F_1(1,95)=1.40$, MSe=1923, $p=0.24$). So, at best, the dissociation in transition effects between the Neutral and the Anomalous Verb environments for the first two prime length positions can be taken as a marginal indication of a differential processing influence due to verb context. The overall evidence, however, argues against any independent status of the factor Verb Type. As shall become apparent in the now following section on the Constraining Context data, the null-effects of Verb Type are very persistent.

Analysis of the Constraining Context results

Table 11 lists the mean naming latencies over subjects for the Anomalous and Neutral Verb environments, as a function of prime length. These numbers are also represented in Figure 8.

Table 11: Constraining Contexts, mean naming latencies for targets, by verb type and prime length.

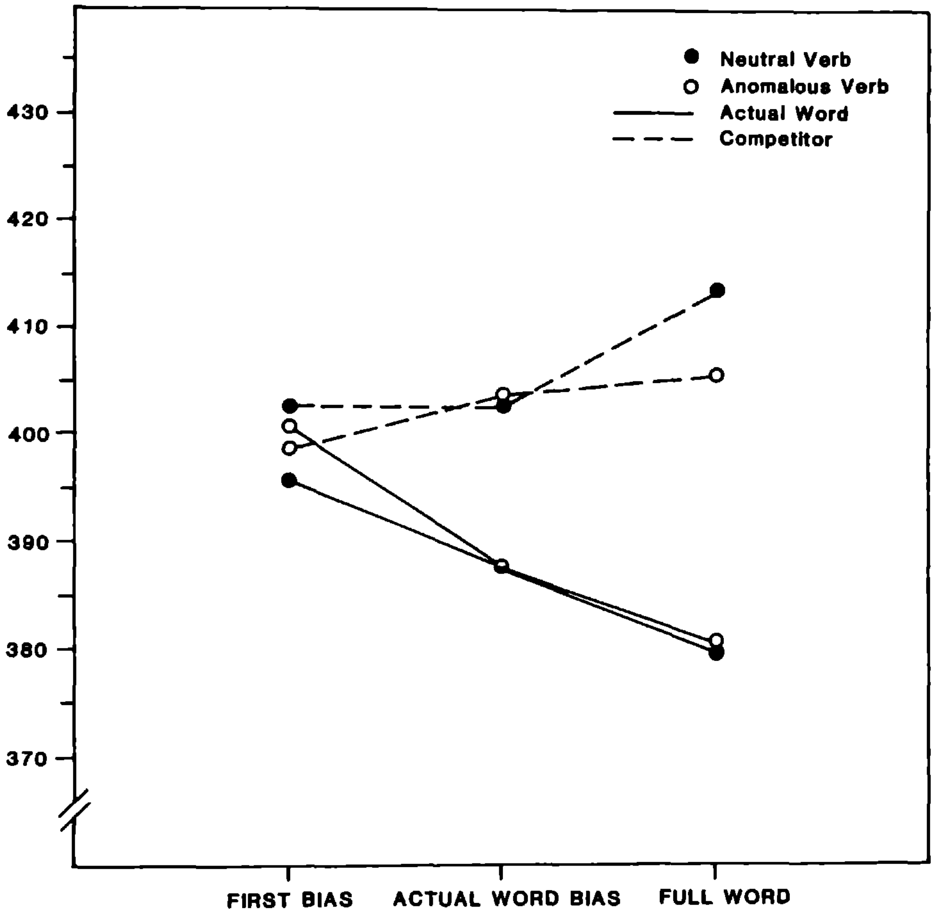
	Prime Length					
	First bias		AW – bias		Full word	
	Anom	Neut	Anom	Neut	Anom	Neut
Actual Word	401	396	388	388	381	380
Competitor	399	403	404	403	406	414

The subject analysis of variance reveals a significant main effect for the factor Target, and a significant Target by Prime Length interaction. No other main or interaction terms reach significance. The relevant statistics are:

Target	$F_{1,95} = 66.13$	MSe=1106	p<0.01
Prime Length	$F_{2,190} = 1.14$	MSe=1982	p=0.32
Verb Type	$F_{1,95} < 1.00$	MSe=2045	p=0.77
Target X Prime Length	$F_{2,190} = 13.54$	MSe=1272	p<0.01
Target X Verb Type	$F_{1,95} < 1.00$	MSe=2166	p=0.37
Prime Length X Verb Type	$F_{2,190} < 1.00$	MSe=1911	p=0.74
Target X Prime Length X Verb Type	$F_{2,190} < 1.00$	MSe=2478	p=0.73

As in all of the previous research, the factor Verb Type does not have any significant effect. Separate analyses by Actual Words and by Competitors also do not show effects for the verb manipulation (both Fs<1.00). Furthermore, as was the case in the preceding Neutral Context data, for both the Actual Words and for the Competitors none of the within prime length position comparisons between the Anomalous and the Neutral Verb environments reaches significance (all Fs<1.00). The largest difference is 8 msec in the wrong direction, for the Competitors at the Full word position ($F_1(1,95)<1.00$, MSe=2844, p=0.31). So, these final results on the effects of verb context once again provide no support for any differential processing consequences of the lexical-semantic information represented at the level of the Anomalous and the Neutral Verbs. In this respect, the experimental programme reported in this dissertation has resulted in a resounding null-effect. The possible causes and implications of this result will be discussed in the final chapter.

Figure 8: Mean naming latencies for Actual Words and Competitors in Constraining Contexts, as a function of verb type and prime length.



Moving to the transition effects, a separate analysis of variance for the Competitor targets does not show a significant effect of Prime Length ($F_1(2,190)=2.42$, $MSe=1673$, $p=0.09$). The transitions are essentially flat. The only exception is the 11 msec difference for Neutral Verb environments between the Actual Word bias and the Full word position. Although indicative of an interference effect, this difference does not reach significance ($F_1(1,95)=2.01$, $MSe=2890$, $p=0.16$). These results almost mirror those obtained in the first Constraining Context experiment, and again highlight the variability over the various experiments of the processing consequences for the Competitor targets of manipulating the auditory input.

The processing profile for the Actual Words seems to reflect an influence of the accumulating auditory information. However, although the two 8 msec transition effects in the Neutral Verb environments between the First bias and the Actual Word bias, and the Actual Word bias and the Full word positions are in the right direction, both are not significant (respectively: $F_1(1,95)=2.02$, $MSe=1385$, $p=0.16$; $F_1(1,95)=1.77$, $MSe=1802$, $p=0.18$). Similarly, the 7 msec difference between the Actual Word bias and the Full word position in the Anomalous Verb environments does not attain significance ($F_1(1,95)=1.31$, $MSe=1983$, $p=0.25$). The only significant transition effect is the 13 msec difference in the Anomalous Verb environments between the First bias and the Actual Word bias positions ($F_1(1,95)=5.72$, $MSe=1334$, $p=0.02$). Not only does this effect underscore the lack of a negative effect due to the Anomalous Verbs, it also undermines the interpretation given above of the dissociation in transition effects in the Neutral Context data between the Neutral and the Anomalous Verb environments for the first two prime length positions. There it was pointed out that this dissociation could be taken as an indication of a negative processing effect caused by the Anomalous Verb environments. This interpretation loses a lot of its value in the light of the significant transition effect observed in the Constraining Context data. In conclusion, other than the one significant transition effect for the Actual Words, the observed results are very similar to the results obtained in the first Constraining Context experiment.

Analysis of the Neutral versus Constraining Context results

To compare and contrast the effects of sentential-semantic information, an analysis of variance was performed on the combined datasets of the Neutral and the Constraining Contexts. As in the previous combined analysis, the data were first normalized for individual subject effects. The same normalization procedure was used. Here again it is apparent that the subject variances in the two populations are very constant: the normalization procedure results in differences of maximally 4 msec between the normalized and non-normalized datasets. Table 12 lists the mean normalized naming times over subjects for the Neutral and Constraining Contexts, as a function of Verb Type and Prime

Length. These numbers are also represented in Figures 9a and 9b.

Table 12: Neutral and Constraining Contexts, mean normalized naming latencies for targets, by verb type and prime length.

	Neutral Context					
	Prime Length					
	First bias		AW – bias		Full word	
	Anom	Neut	Anom	Neut	Anom	Neut
Actual Word	401	407	397	390	383	376
Competitor	403	408	401	410	410	414
	Constraining Context					
	Prime Length					
	First bias		**AW – bias**		**Full word**	
	Anom	**Neut**	**Anom**	**Neut**	**Anom**	**Neut**
Actual Word	404	399	391	391	384	383
Competitor	403	406	407	406	409	417

The analysis of variance statistics are:

Sentential Context	$F_{1,190}$ = 0.00	MSe= 0	p=1.00
Target	$F_{1,190}$ = 119.58	MSe=1183	p<0.01
Prime Length	$F_{2,380}$ = 5.24	MSe=1854	p<0.01
Verb Type (VT)	$F_{1,190}$ < 1.00	MSe=1941	p=0.53
Target X Prime Length	$F_{2,380}$ = 27.81	MSe=1445	p<0.01
Target X Verb Type	$F_{1,190}$ = 2.94	MSe=2355	p=0.09
Prime Length X Verb Type	$F_{2,380}$ < 1.00	MSe=1760	p=0.90

Figure 9a: Mean normalized naming latencies for Actual Words in Neutral and in Constraining Contexts, as a function of verb type and prime length.

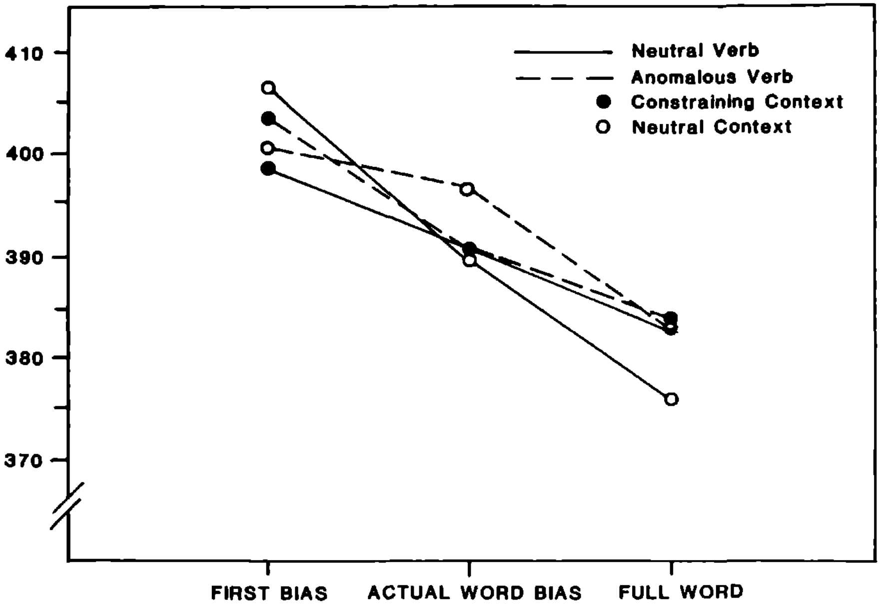
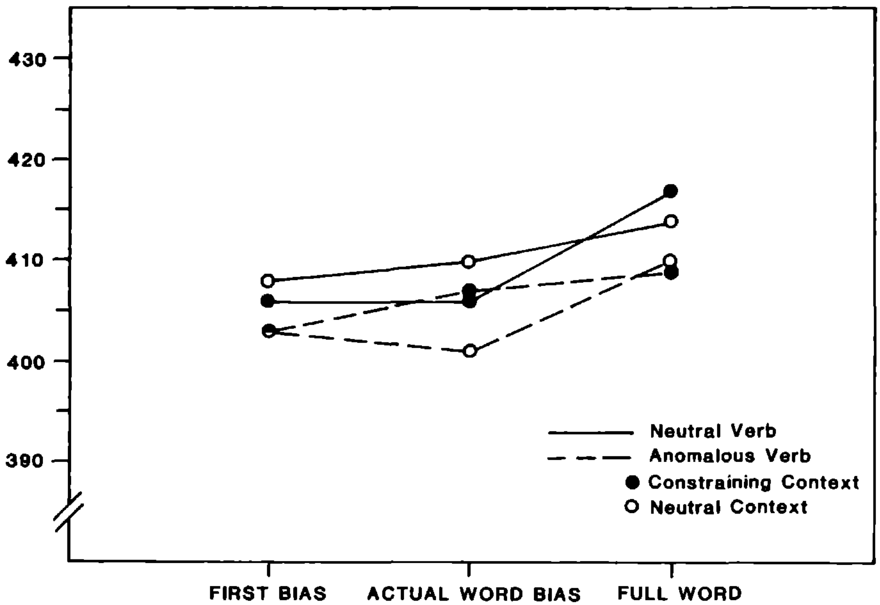


Figure 9b: Mean normalized naming latencies for Competitors in Neutral and in Constraining Contexts, as a function of verb type and prime length.



Target X Prime Length X Verb Type	$F_{2,380} < 1.00$	MSe=2537	p=0.83
Sentential Context (SC) X Target	$F_{1,190} < 1.00$	MSe=1183	p=0.99
SC X Prime Length	$F_{2,380} < 1.00$	MSe=1854	p=0.52
SC X Verb Type	$F_{1,190} < 1.00$	MSe=1941	p=0.88
SC X Target X Prime Length	$F_{2,380} < 1.00$	MSe=1445	p=0.70
SC X Target X Verb Type	$F_{1,190} < 1.00$	MSe=2355	p=0.61
SC X Prime Length X Verb Type	$F_{2,380} < 1.00$	MSe=1760	p=0.41
SC X Target X Prime Length X VT	$F_{2,380} < 1.00$	MSe=2537	p=0.42

The overall null-effect of sentential-semantic information is even more resounding than in the first combined analysis. All the F-values for the interaction terms which include Sentential Context as a factor are below 1.00. Separate analyses of variance on the data for the Actual Words and for the Competitors also show that Sentential Context has not in any way affected the processing of the target words. The only significant result that does emerge in both of the analyses is a main effect for Prime Length (Actual Words: $F_1(2,380)=26.49$, MSe=1654, $p<0.01$; Competitors: $F_1(2,380)=3.71$, MSe=1645, $p=0.02$). This main effect arises from the separate effects of Prime Length in the Neutral and in the Constraining Contexts, and has been further analyzed and discussed in the preceding sections on these separate datasets.

The critical test of any differential processing effect due to sentential-semantic information is the comparison at each prime length position, for each verb type, between the Neutral and the Constraining Contexts. Not one of these comparisons reaches significance. Taking into account the previously reported non-significant effects in the combined analysis for the first Neutral and Constraining Context experiments, the present results definitely sound the death bell for the factor Sentential Context as realized and assessed here.

Summary

With the tolling of the bell, the end of the experimental programme of this dissertation has been reached. Before moving to the final chapter, I will briefly sum up the results of the experiments on semantic-context effects during spoken-word processing.

In the first experiments, the relative sentential-semantic appropriateness of the Actual Words, as well as the inappropriateness of the Competitors was manipulated. This did not result in any differential processing effects for the Actual Words or for the Competitors. Furthermore, no influence was observed of the clash between the lexical-semantic information of the verb preceding the auditory prime, and the semantic information of the visual Competitor target. To assess whether the obtained null-effects were due to the specific temporal parameters of the experimental procedure, a time-delay of either 100 or 500 milliseconds was inserted between the offset of the auditory prime and the presentation of the visual target. This increase in the amount of available processing time did not yield significant effects of the contextual manipulations. Finally, to determine whether the absence of lexical-semantic effects was due to the fact that this variable had not been realized at the level of the primary auditory analysis process, two experiments were performed where the lexical-semantic variation was manipulated in the spoken material. Once again, no processing effects of contextual information were observed.

At this point, it is time to take a step back from the specifics of the various experiments that have been performed, and to discuss the wider implications of the overall absence of effects of the contextual manipulations. This is the main topic of the following, concluding chapter.

4 CONCLUDING REMARKS

Concluding chapters usually serve the purpose of presenting an interpretative framework in the form of a new or revised model, and of discussing the validity of this model within the domain to which it applies. Unfortunately, the present results provide little scope for such meta-analysis. What started out as an attempt to assess the processing effects of semantic context during spoken-word recognition, evolved into an investigation of persistent null-effects. In this final chapter I will focus on a number of reasons why such effects might have obtained. In particular, I will analyze in some detail the processing and representational assumptions underlying the cross-modal candidate priming paradigm in combination with the naming task. However, before embarking on this analysis, I want to discuss some claims made in the literature on form priming in the auditory modality, which are shown to be invalid by the present results.

The research reported in this dissertation provides evidence for the multiple activation of separate word forms during spoken-word processing. The Carrier Phrase experiment reported in Chapter 2 demonstrates that both the Actual Word and its Competitor become activated on the basis of the analysis of some initial stretch of the acoustic signal of the Actual Word. Further stimulus processing results in a sustained level of activation for the Actual Word, and an interference effect for the mismatching Competitor. These results are at odds with a number of studies recently reported in the literature.

Slowiaczek and Pisoni (1986), and Radeau, Morais, and Dewier (1989) report a number of experiments in which they failed to find evidence for the occurrence of what they refer to as 'phonological priming' during spoken-word processing. In this research, phonological priming is operationalized as the number of phonemes shared between a prime and its target. Subjects listened to fully pronounced prime-target pairs in which the amount of word-initial acoustic-phonetic overlap was varied from one to three phonemes (e.g., prime: step, target: stem), or in which the prime and target were identical. Both studies used an auditory lexical decision task, and Radeau et al. additionally used a shadowing task. The results show facilitation of the target words in full repetition conditions, but no such effect for the partial overlap conditions. In fact, Radeau et al. report an interference effect (in both tasks), and the Slowiaczek and Pisoni data show a similar trend. The latter authors are reluctant to abandon the notion of phonological activation, and, therefore, attempt to explain the absence of partial priming effects by appealing to characteristics of the lexical decision task: "The classification processes involved in lexical decision may be operative at a point at which the phonological information has already been replaced by a more abstract lexical representation" (p.236). In support of this claim, they refer to data obtained with a perceptual identification task by Slowiaczek, Nusbaum, and Pisoni (1987). In this research, subjects identified target words embedded in noise at different signal-to-noise ratios. The words were preceded by primes sharing one, two, three, or all phonemes with the targets. Significant priming was observed in all priming conditions. Moreover, and peculiarly, listeners were also sensitive to overlap at the ends of words (e.g., prime: sand, target: hand), which leads the authors to "call into question the presumed importance of word-initial phonological information in directing the word-recognition process" (p.73). This, however, is carrying the interpretation too far. What is critical here, is that perceptual identification in noise does not yield on-line data. Therefore, it is unclear what, if anything, identification responses are revealing about the on-line lexical analysis process. Particularly in the light of evidence demonstrating the importance of word-onsets for on-line word recognition (e.g., Marslen-Wilson & Zwitserlood, 1989), it is more realistic to assume that the Slowiaczek et al. (1987) results are the product of some off-line guessing procedure, and do not reflect on-line perceptual processes. Radeau et al. have no reservations concerning the relationship between their data and the underlying language comprehension process, and conclude that "The now available evidence on phonological priming thus supports the view that phonological activation, if it ever occurs, does not last long enough to affect perceptual processing of the target" (p.533).

My data present evidence that lexical form priming does occur, and that the physical characteristics of an acoustic prime can exert an on-line effect on the activational state of an immediately following target word. The reason why Slowiaczek and Pisoni (1986) and Radeau et al. (1989) failed to find such effects is because they used full-word primes, thereby effectively confounding form and lexical information. As my data show, in full-form priming situations a lexical mismatch between a prime and its target results in an interference effect. However, when partial primes are used which do not instantiate a lexical mismatch, significant facilitatory effects are found.

Turning now to a consideration of the higher-order variables investigated in this dissertation, the evidence on which to base any processing claims becomes much less firm. Despite a number of efforts, basically no effects could be obtained of verb-contexts or of sentential-semantics. These efforts involved manipulating the amount of available processing time between the stimulation and the moment of response, as well as introducing semantic anomalies at the level of the auditory analysis process. What caused this absence of context effects? Three factors could be involved: (1) the materials, (2) the cross-modal candidate priming paradigm, and (3) the naming task. I can be brief about all three.

As far as the materials are concerned, we are in principle confronted with a veritable flood of possibly contaminating variables. A survey of the psycholinguistic literature on lexical processing could lead the cynic to claim, with some validity, that its history so far is characterized by an increasing number of variables that have to be controlled for in any experiment, with little progress in obtaining a substantial understanding of the nature and structure of the language comprehension system itself. On the occasion of the tenth anniversary of the journal Cognition, Anne Cutler wrote an essay titled "Making up materials is a confounded nuisance, or: Will we be able to run any psycholinguistic experiments at all in 1990?" (Cutler, 1981). Her judicious conclusion at the time was: "The prospects are gloomy. If it goes on this way in the eighties, psycholinguists will literally be lost for words" (p.69). Having reached 1990, it appears that Cutler's gloom was more than justified. Although we are still able to run psycholinguistic experiments, the size of our playing ground is dwindling with each issue of the many language journals that are published with such overwhelming and alarming frequency. By attempting to take all of the mini-facts into account in constructing our stimuli, as well as in selecting our paradigms and tasks, we are in real danger of controlling all the interesting phenomena away.

With respect to the present material, there is no reason to assume that variables intrinsic to the set of target words are in some way confounding the true effects of the experimental manipulations. The carrier phrase experiment clearly demonstrates that the Actual Word and Competitor target words are not exerting any differential influence on the basis of their lexical characteristics. For the auditory stimulation it is more difficult to be sure that the experimental variables were appropriately operationalized. This does not hold so much for the verbal contexts - the semantic anomalies are quite straightforward - but it is a consideration for the sentential-semantic contexts. As I pointed out in the section on stimulus selection in Chapter 3, a constant worry in experiments on the locus of the effects of sentential-semantic information is whether the material used excludes interpreting obtained effects in terms of intra-lexical priming processes. The way in which I tackled this problem was to pretest the Constraining Contexts in a cloze procedure, and to use only those sentential frames in which the cloze-value for the Actual Word did not exceed 0.20 (with a permissable range of 0.10). This implies that the Actual Words are no more than moderately predictable, which is an important factor in arguing against sophisticated guessing strategies during on-line lexical processing. However, this also entails that the semantic information of the Constraining Contexts could in fact have been insufficient to bring about a bias for the Actual Words, relative to the Neutral Contexts. In other words, the absence of sentential-semantic context effects could be due to insufficient informational separation between the Constraining and the Neutral Contexts. In the absence of an articulated theory of the semantics of natural languages, this remains a moot point. However, I believe that the Constraining Contexts do in fact live up to their label. The cloze-value used for these sentences is almost the same as the 0.25 level employed by Zwitserlood (1989a,b) to operationalize her biasing contexts, and she reports strong effects relative to the same kind of neutral contexts as used in the present experiments.

Concerning the paradigm, the carrier phrase experiment indicates that candidate priming with partial acoustic primes is a viable procedure to measure on-line lexical processing effects. The observed multiple activation of lexical entries, together with the changes in the activational profile as a function of increasing stimulus information, implies that the cross-modal paradigm used in this dissertation research is sufficiently sensitive to pick up on differential levels of lexical activation. However, the sensitivity of the cross-modal candidate priming paradigm has only been examined in combination with the naming task. This constrains the validity of the paradigm to those processing events that can be tapped into by the naming task, which brings me to a consideration of the third possible factor underlying the observed null-effects.

As I pointed out at some length in Chapter 1, there is a debate going on concerning a possible non-lexical route to pronunciation. Such a route could be the primary cause of the present results. If it is the case that naming normally proceeds without any involvement of the mental lexicon, then obviously one would not expect to pick up on semantic-context effects with this task. In defence of naming as a lexical process, I refer, first, to the arguments presented in the introductory chapter, in particular concerning the evidence from semantic priming, and maintain my position that - under the appropriate stimulus conditions - the naming task does tap into on-line lexical processes. Second, the results from the carrier phrase experiment indicate an involvement of the mental lexicon. The fact that an interference effect is observed on the basis of the lexical mismatch between the fully pronounced Actual Word and its visual Competitor, is not readily compatible with a pre-lexical characterization of the naming task.

On the basis of the preceding discussion, it seems unlikely that a particular factor should be pinpointed as the sole cause of the overall lack of context effects. However, it is possible that a 'conspiracy factor' is involved, resulting from the specific combination of cross-modal candidate priming and naming. Two such possibilities need to be considered.

First, it could be the case that despite their individual diagnostic value, the combination of cross-modal candidate priming with naming is inappropriate for the questions posed in this dissertation. I used this particular configuration because I wanted to try and tap into the ongoing process as directly as possible, with minimal contamination from the stimulus situation and from the task. This is why I chose candidate priming as opposed to semantic priming, partial priming as opposed to only full-word priming, and naming as opposed to lexical decision. The danger here is that by stripping the measurement procedure to its barest bones, the processing load due to the stimulus and task environment might be so low, that the subjects are able to perform with near optimal efficiency and speed, thereby minimizing at the level of the reaction-time data possible differential effects caused by the experimental variables. The data provide some support for this possibility. The overall naming latencies in the experiments reported here are very short (the grand average for all of the context experiments is 393 msec, with a 7 msec range), the variance is low (standard errors often do not exceed 20 msec), and the subjects made very few errors. If we recollect that the only other source of directly relevant data comes from Zwitserlood's (1989b) cross-modal semantic priming work with the lexical decision task - which did reveal significant context effects - then maybe it is the case that this dissertation is the victim of an overly ascetic experimental procedure.

The second possibility is that the particular combination of candidate priming with naming is tapping into only the level of lexical forms. If, given the experimental procedure used here, these form representations are not affected by semantic representations, then this would explain why no effects of semantic context have been observed. The issue here concerns the processing and representational assumptions involved in the naming task and in the cross-modal candidate priming paradigm. It is related to the issue of the previously discussed non-lexical route in naming, in the sense that it similarly excludes effects arising from lemma representations. However, the exclusion is less principled, because the pronunciation process is assumed to proceed via the mental lexicon. That is, within a processing domain where both form and lemma representations reside. With respect to the lexical process of naming a written word, in principle two different routes within the lexicon can be distinguished. On the one hand, naming could proceed via a link between orthographic and phonological form representations within the mental lexicon, without involvement of semantic representations. On the other hand, naming could involve a semantic representation, linked with form representations, which would allow for differential pronunciation effects on the basis of the semantic structure of the lexicon. Two quite uncontroversial assumptions are involved here. One is that there are at least two qualitatively distinct representations within the mental lexicon: form representations containing orthographic and phonological information, and lemma representations containing lexical-semantic information (cf. Kempen & Huijbers, 1983; Levelt, 1989). The other is, unsurprisingly, that the level of lexical meaning representations is implicated in semantic-context effects.

With respect to cross-modal candidate priming, the form representation of the auditory prime is assumed to make contact with the phonologically recoded representation of the visual target, which mediates between the orthographic representation of the target and its articulatory code. The phonological representation of the target receives activation from the form representation of the prime. The degree of activation is a function of the extent of the informational overlap between the prime and the target. The level, then, at which the activational effects induced by candidate priming are primarily operative, is the form representation level. With cross-modal stimulation using semantically constraining utterances (as in the Constraining Contexts of this research), it is assumed that the activational level of the semantic representation of the auditory prime is affected by its preceding semantic context. When the auditory prime and the visual target match, the semantic representation for the two is the same, so that the activational level of the visual target is likewise affected by the sentential context. This implies that when using the naming task in combination with the cross-modal candidate priming paradigm, semantic context effects will only be observed if the lemma representation of the matching prime-target stimuli affects the phonological (and/or articulatory) representation of the visual target.

Now, it can be posited that candidate priming does not necessarily involve contact with semantic information at the level of either the prime or the target words, and that naming does not necessarily involve a lexical-semantic representation of the visual string. Therefore, it could be the case that the process of pronouncing written words preceded by form-related primes is not tapping into the meaning representation level, which would explain why no effects of semantic-context were measured.

The preceding information-processing analysis of the experimental procedure used in this dissertation contains a possible explanation for the discrepancy between the present results on context effects on spoken-word processing, and the results of Zwitserlood (1989a,b). As I discussed in Chapter 1, Zwitserlood used a cross-modal semantic priming paradigm with a lexical decision task, and obtained significant processing effects of sentential-semantic contexts. There are two important differences between Zwitserlood's research procedure and mine. She used semantic priming, whereas I used candidate priming, and she used the lexical decision task, whereas I used the naming task. If we analyze which representational levels are being tapped into in cross-modal semantic priming, then although a form level has to be involved given the necessity to map the sensory information onto entries in the mental lexicon, it seems clear "... that the level of representation involved in semantic priming is the lexical-semantic level" (Zwitserlood, 1989b, p.151). In the cross-modal semantic priming approach it is assumed that activation spreads from the lemma representation of the auditory prime to the lemma of the visual target via lexical-semantic links in the lexicon. According to Zwitserlood, the effect of sentential-semantic information in her research was to modulate the activational level of the lemma representation of the auditory prime, which in turn affected the activational level of the visual target. Note that this analysis of the processing effect of contextual information is essentially the same as I have put forward for cross-modal candidate priming. The main difference is that in candidate priming the additional assumption of lexical-semantic spreading activation within the lexicon does not have to be made. With respect to the lexical decision task, Zwitserlood's results indicate that meaning representations within the mental lexicon are involved in the response. Although lexical decision could be achieved on the basis of only an orthographic form representation of the visual target (cf. Seidenberg & McClelland, 1989; but see Besner, Twilley, McCann, & Seergobin (1990) for a critique; see Seidenberg & McClelland (1990) for a reply to Besner et al.), the fact that Zwitserlood obtained differential processing effects as a function of variously constraining sentential-semantic contexts, implies that the lemma representation was exerting an influence during the response process. Here, then, is a possible explanation for the discrepancy between Zwitserlood's and my results. Her semantic priming paradigm in combination with lexical decision would seem to involve meaning representations within the lexicon, whereas my candidate priming paradigm with a naming task might tap into only form representations.

The postulated separation of form and meaning representations within the mental lexicon, together with the functional analysis of the naming task, provides an explanatory framework for the null-effects obtained in this dissertation. This information-processing account raises some methodological questions for future research on cross-modal priming with naming, as well as with lexical decision. In particular, it will be interesting to investigate the kinds of processing effects that obtain with naming using the sentential material of my dissertation research, but now with semantic associates of the Actual Words and Competitors. If once again no effects of semantic context are observed - even when including a 500 millisecond ISI-manipulation - then this would strongly support the idea that in a cross-modal priming situation, the naming task is not tapping into lemma representations. Furthermore, it will be interesting to ascertain whether semantic-context effects can be picked up in a cross-modal candidate priming paradigm, when the task is lexical decision on the visually presented targets. If this turns out to be the case, then the candidate priming paradigm is further validated as an appropriate procedure for on-line lexical processing research.

Finally, if we put aside any and all reservations concerning the paradigm and task, and for a moment accept the data at face value, then they have clear implications for the psychological reality of different classes of word-recognition models. First and foremost the results argue against the all-or-none and the interactive-activation models. At no moment in time during the analysis of the Actual Words is there any indication of an influence from higher-order semantic representations. This lack of an effect is more in line with the processing claims of autonomous processing models. However, given the absence of verb-context effects, the results argue against those autonomous models which assume that some form of semantic information is represented within the lexical processing domain. Despite endeavours to manipulate lexical- and sentential-semantic information, the whole experimental programme can be construed at the level of the data as basically a series of carrier phrase experiments. The only kind of processing model that fits the overall pattern of results is a model which assumes a skeletal lexical processing environment, consisting solely of a collection of form representations (with a possible weighting according to frequency characteristics). In sum, the kind of model as described by Forster (1979).

The danger in accepting things at face value is that the picture they present may only be a chimera, occluding the underlying reality. Null-effects are notorious in this respect, and this is the reason why I feel that the data of this dissertation should not be taken as clear evidence for or against any particular processing characterization of spoken-word recognition. After having tested some 750 subjects in a variety of experiments on lexical processing, it is perhaps tempting to conclude with a substantial statement on the nature of language comprehension. However, confronted with the persistent null-effects of the present research, caution should prevail. Despite the quotation from Bacon with which I began this dissertation, the obtained negatives lead me to silence in the end. Such is science. At times.

NOTES

Chapter 1

1. Within certain classes of processing models the distinction between lexical selection and integration is elusive, and its functional value might be questioned. So, for instance, take an interactive processing model which posits that higher-order information affects the activational status of multiple lexical candidates, such that the activational level of certain candidates within the instantiated lexical pool is decreased because of their inappropriateness with respect to a higher-order representation of the utterance, whereas the activational level of appropriate candidates is increased (e.g., McClelland and Elman's Trace model). Does this kind of postulated activational modulation reflect operations of the selection or of the integration function, or does this separation no longer apply? Similarly, take a model which claims that the instantiation and initial reduction of the lexical pool proceeds in a bottom-up, strictly autonomous manner, following which higher-order information is used to assess the relative appropriateness of the remaining candidates (e.g., Norris' checking model). Does this assign a post-selectional locus to the processing effects of higher-order information? These questions show, as I indicated earlier, that a neutral and encompassing functional definition of the word-recognition process is not really possible. Nevertheless, I do believe that the trichotomous taxonomy into access, selection, and integration functions is important. In particular because it captures the essential difference between autonomous and interactive processing models, namely whether lexical identification does or does not proceed on the basis of bottom-up stimulus information alone. Furthermore, it provides a clear framework for an empirical programme on the locus of context effects during spoken-word recognition, refining the general question of "Can higher-order information affect lexical processing?" to "Is the unique identification within the mental lexicon of a spoken word affected by information that is represented outside the lexicon?". Partitioning the word-recognition process into access, selection, and integration functions has, therefore, a heuristic and a diagnostic value. The functional analysis rises above the processing and implementational variations among individual models, and provides the conceptual distance which is required to compare and weigh these models. Whether this taxonomy is psychologically real is of course an empirical issue, which is in part addressed in this dissertation.

2. A possible approach here is the real-time registration of event-related brain potentials (ERPs) during language comprehension. In particular the so-called N400 component shows real promise for investigating semantic processing (see Kutas & Van Petten (1988) for an overview). The fact

that ERPs provide a continuous measure of ongoing information processing in the brain, together with the fact that they can be registered in the absence of any interfering task, makes them a very interesting measure for on-line processing experiments. However, at present it is unclear what kinds of processing events are reflected by ERPs. For instance with respect to the N400, there is uncertainty whether this component taps into automatic or into controlled processing aspects of the language comprehension system (cf. Brown, Hagoort, & Swaab, 1989). It is to be hoped that registering ERPs will turn out to be a truly on-line and direct measure of language processing, but before this hope materializes a considerable amount of research remains to be performed.

3. Moreover, despite claims concerning the purported regularity of shallow orthographies, in practice it has turned out to be basically impossible to create an algorithm that reliably maps grapheme-phoneme codes onto lexical items, without making reference to dictionary information, such as lexical stress. There simply are too many exceptions (Kempen, personal communication).

Chapter 2

1. This particular operationalization of the informational value of the partial priming conditions resembles Zwitserlood's (1989a,b) Isolation and Recognition Point conditions (cf. Marslen-Wilson, 1984). However, in the present research I am not directly concerned with the processing implications of isolation and recognition points. The First and Actual Word bias conditions are intended to create differing degrees of ambiguity of the signal with respect to possible lexical candidates. Both biasing conditions lie before the recognition point as operationalized by Zwitserlood.

2. In addition to the stimulus information conveyed by the signal of the Actual Word, it can be argued that the prosodic structure of the whole carrier phrase is a source of information for the listener. There is some evidence which suggests that listeners do exploit prosodic cues during processing (e.g., Cole, Jakimik, & Cooper, 1978; Cutler, 1989; Cutler & Foss, 1977; Lieberman, 1963), but there is also evidence to the contrary (Cutler & Clifton, 1984; Cutler, 1986). This uncertain state of affairs does not affect the reaction-time research reported in this thesis. The reason is that in as far as the prosodic structure of the input contributes to the ongoing processing, this is a constant factor in the experiments: the experimental manipulations and comparisons of Actual Words are always performed within identical sentential frames.

3. It could be argued that an interference effect might occur at an early moment during stimulus processing - certainly well before the Full word position - caused by a mismatch between the auditory input and the grapheme-to-phoneme recoded visual input. To date, there is no directly relevant evidence available in the literature concerning cross-modal activation with partial primes in the lexical domain. However, a recent study by Dijkstra (1990; see also Dijkstra, Schreuder, & Frauenfelder, 1989) on cross-modal contacts between graphemes and phonemes (i.e., the sub-lexical domain) shows that whereas facilitation effects do obtain between the visual and the auditory modalities, no cross-modal interference effects are observed.

4. In fact, this finding raises the question of how one can be at all sure that at some point in time - for instance somewhere like at the ephemeral Recognition Point - only one word, in this case the Actual Word, is being considered for identification. Given the implications of the preceding discussion concerning the null-effect for the Gating versus Dictionary Competitor comparison, the answer has to be that basically one cannot be sure. The only criterion available with gating data is the number of subjects responding with the Actual Word (with a possible weighting according to the confidence ratings). Even if at some point all of the subjects produce the Actual Word, it still remains uncertain whether this implies that other words are no longer being considered as possible candidates for identification. In this respect it is important to emphasize that the experiments reported in this thesis are not directly concerned with defining functionally distinct aspects of the input signal (like Recognition Points, or whatever). Nor is it critical to know at specific moments in time exactly which words are viable candidates in the ongoing process. The experiments exploit the basic phenomenon of multiple-word activation to investigate on-line lexical processing, but full knowledge - if at all possible - of the momentary composition of an activated lexical set is not required.

Chapter 3

1. Given the subtleties of the contextual manipulations, I prefer to give examples of the actual Dutch material used in the experiments. An approximate (more than stilted) English translation is:

   Everyone was very motivated to make the best of it.
   The men were busy all day.
   One of them bought a bath. Target: BATH / BALL

The plumbing in the villa badly needed replacing.
The men were busy all day.
One of them bought a bath. Target: BATH / BALL

2. It can be argued that it is incorrect to say that the discourse focus is brought about by sentential-semantic information, because it originates from the semantic domain of single words, like 'sanitair' in the example. This is a perennial problem when making distinctions between sentential and lexical semantics, and it will be addressed in the section on stimulus selection. For the present, it can be noted that the focussing words of the discourses are not closely related to their Actual Words. This was verified both by independent judges, and by checking the existing association norms for Dutch.

3. The relevance of this distance is that it provides an additional argument against claiming that any observed sentential-semantic processing effects are in fact the result of intra-lexical semantic links between content words in the discourse and the target words. Although there is little data available on the dissipation of lexical semantic priming effects within sentential contexts, there is some evidence that in naming tasks the effect of interposing words between primes and targets in standard word-priming experiments, is to eliminate priming effects due to the semantic relationship between the prime and the target (cf. Neely, 1990; but see Foss, 1982).

4. It was decided that it was unnecessary to pretest the Neutral Contexts. Four experienced judges all agreed that these discourses are so unconstraining that any number of semantically distinct words can serve as completions. Similarly, the Competitor targets in the Constraining Contexts with Neutral Verbs were judged to be so unnatural in combination with these discourses, that a cloze procedure was considered to be operationalizational overkill.

5. In fact, slight differences do arise between the error terms for the normalized and non-normalized data, caused by the three-decimal precision of the normalization procedure.

6. With respect to the central comparison between the Actual Words and the Competitors in the experimental programme being presented here, it is important to note that the observed overall reaction-time difference between the two item-sets in the first Neutral Context experiment does not enter into any interactions with the experimentally manipulated variables. The dummy factor ISI results in a significant main effect, but not in any significant interaction. Moreover, the size of the overall

reaction-time difference between the Actual Words and the Competitors in the first Neutral Context experiment is practically the same as in the ISI-experiment (20 and 21 msec, respectively), which shows that at this level of the data the item-differences are irrelevant.

7. Shapiro et al. (1987, 1989) did use a cross-modal presentation, with spoken sentences and visual target words, however their approach is very different from the present one. They focussed only on syntactic aspects of verbs, using a lexical decision task with visual probes that were not in any way related to the content of the sentence, no partial primes were used, and no form of anomaly due to verb-context was present at the level of the auditory or the visual input.

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APPENDIX 1

Actual Words with Gating Competitors

The first word of each pair is the Actual Word.

beurt	dreumes	snoep	straf	knapen	breken
beurs	dreunen	snoek	strak	knagen	brede
kalk	grap	berken	kluif	filmen	vloek
kalf	gram	bergen	kluis	filter	vloed
bad	krat	duit	strijden	kuit	aak
bal	krap	duin	strijken	kuip	aap
fuik	stoot	mok	schop	sluis	dwazen
fuif	stoom	mond	schok	sluik	dwalen

Actual Words with Dictionary Competitors

The first word of each pair is the Actual Word.

harp	luik	heupen	tuig	schap	keuze
hars	luid	heugen	tuit	schaft	keutel
donder	mus	stop	griep	klop	schuif
donzen	muf	stof	grief	klos	schuit
wreken	sloot	zoek	boot	masker	fractie
wrevel	sloof	zoen	boog	mastiek	fractuur
pek	blaag	dressuur	strik	buik	gordel
pet	blaam	dreggen	strip	buil	gortig

APPENDIX 2

Test sentences with their targets

Codes: CC = Constraining Context
NC = Neutral Context
FS = Filler Sentence
AV = Anomalous Verb
NV = Neutral Verb

Conditions:	Neutral Context, Anomalous Verb	= NC + FS + AV
	Neutral Context, Neutral Verb	= NC + FS + NV
	Constraining Context, Anomalous Verb	= CC + FS + AV
	Constraining Context, Neutral Verb	= CC + FS + NV

The first target word is the Actual Word.

CC: Het cabaretgezelschap trekt volle zalen over het hele land.
NC: De groep probeert ervaring op te doen door situaties na te spelen.
FS : Het jongste lid mag altijd als eerste beginnen.
AV: Hij vertelt een grap / gram
NV: verkoopt

CC: Het sanitair in de villa was nodig aan vervanging toe.
NC: Iedereen was zeer gemotiveerd om er het beste van te maken.
FS : De mannen waren de hele dag druk bezig.
AV: Een van hen installeerde een bad / bal
NV: kocht

CC: De biljarters bereiden zich voor op het grote toernooi.
NC: Het evenement trekt steeds weer grote aantallen toeschouwers.
FS : De geluksvogel van vorig jaar maakt ook nu weer goede kansen.
AV: Hij oefent de stoot / stoom
NV: bekijkt

CC: De suikermagnaat besloot om een nieuwe markt aan te boren.
NC: De marktsituatie is verbeterd in vergelijking met de voorafgaande periode.
FS : De slimme man ziet dat er volop mogelijkheden zijn.
AV: Hij fabriceert snoep / snoek
NV: verkoopt

CC: Het graven van de rioolput duurde nu al zo'n vier uur.
NC: De omstandigheden waren verre van ideaal.
FS : De man kon niet goed werken in de kleine ruimte.
AV: Hij gebruikte een schop / schok
NV: kreeg

CC: Een groot aantal snaren was geknapt tijdens het transport.
NC: In alle drukte had men de laatste voorbereidingen over het hoofd gezien.
FS : De vrouw moest snel het nodige vervangen, wat net op tijd lukte.
AV: Zij stemt de harp / hars
NV: probeert

CC: De koetsiers brengen veel tijd door met het onderhouden van hun materieel.
NC: De technologie maakt handwerk steeds meer overbodig.
FS : De oude man werkt nog op ambachtelijke wijze.
AV: Hij verstelt een tuig / tuit
NV: maakt

CC: De mariniers bereiden zich voor op de komende oefening.
NC: Er moet nog veel gebeuren voordat er begonnen kan worden.
FS : De ervaren man is aangewezen als de verantwoordelijke persoon.
AV: Hij bestuurt de boot / boog
NV: bekijkt

CC: De jager is al de hele nacht op zoek.
NC: Ondanks voortdurende pogingen wil het alsmaar niet lukken.
FS : De man wil eindelijk wel eens iets mee naar huis kunnen nemen.
AV: Hij knoopt een strik / strip
NV: koopt

CC: De veelvraat keek met instemming naar de uitgestalde waren.
NC: Door de drukte waren er lange wachttijden ontstaan.
FS : De man was er met het verstrijken van de tijd niet op vooruit gegaan.
AV: Hij vult zijn buik / buil
NV: toont

CC: De kandidaten moesten morgen iets over hun werk vertellen.
NC: Het beloofde een zware dag te worden.
FS : Peter nam zich voor dat hij flink zijn best zou doen.
AV: Hij oefende zijn beurt / beurs
NV: kreeg

CC: Palingen zijn doorgaans moeilijk te vangen.

NC: De situatie was door de gebeurtenissen verslechterd.
FS : De mannen besluiten om een traditionele methode toe te passen.
AV: Zij plaatsen een fuik / fuif
NV: geven

CC: De honden weten dat er iets op komst is.
NC: Bij een dergelijke groep weet je nooit wat je moet verwachten.
FS : Zij zitten allemaal rustig af te wachten.
AV: Een van hen verslindt de kluif / kluis
NV: bekijkt

CC: De wielrenner voelde plotseling een hevige pijnscheut.
NC: Als de concentratie verslapt is een ongeluk gauw gebeurd.
FS : De man raakte flink uit evenwicht.
AV: Hij verrekte zijn kuit / kuip
NV: grijpt naar

CC: De koe van boer Gerrits was in moeilijkheden geraakt.
NC: Het was laat in de middag toen het voorval plaatsvond.
FS : De knecht moest het alleen opknappen.
AV: Hij stapt in de sloot / sloof
NV: bekijkt de

CC: Vanaf de kantelen verdedigden de ridders en het voetvolk hun burcht tegen de aanstormende Gothen.
NC: De opdracht moest zo snel mogelijk uitgevoerd worden.
FS : Ook de vrouwen hielpen mee.
AV: Zij mengden de pek / pet
NV: pakten

CC: De kleine belhamel had een enorme troep gemaakt.
NC: Even leek het erop dat de zaak uit de hand zou lopen.
FS : De man vond dat er opgetreden moest worden.
AV: Hij berispte de blaag / blaam
NV: negeerde

CC: Het virus slaat zoals ieder jaar weer in alle hevigheid toe.
NC: Vaak zijn de traditionele oplossingen nog de beste.
FS : De vrouw probeert een middel dat zij van haar grootvader geleerd heeft.
AV: Het geneest de griep / grief
NV: verzacht

CC: In het rek konden de kunstboeken niet rechtop staan.
NC: Er moest nog veel gebeuren.

FS : Jan begon de boel te veranderen.
AV: Hij verhoogde de schap / schaft
NV: gebruikte

CC: Hans weifelde erg tussen de hem voorgelegde onderwerpen.
NC: Al met al bleek dit niet Hans z'n beste dag te zijn.
FS : De jongeman staarde lange tijd naar de grond voordat hij verder ging.
AV: Hij verdedigde de keuze / keutel
NV: ontweek

CC: De beveiliging van de buitendeur laat te wensen over.
NC: De onderhoudskosten zijn de laatste tijd flink gestegen.
FS : De huurder weet een simpele en goedkope oplossing.
AV: Hij monteert de schuif / schuit
NV: repareert

CC: Om niet herkend te worden op het nieuwjaarsbal verliet de prins al voor twaalven het bal.
NC: Ondanks alle inspanningen was de man niet tevreden met zijn werk.
FS : Plotseling neemt hij een besluit.
AV: Hij verfrommelt het masker / mastiek
NV: vernielt

CC: Tijdens de kamerdebatten over de onderzeeboten trad de partij sterk op de voorgrond.
NC: Er werd gediscussieerd over de betreurenswaardige gebeurtenissen.
FS : De man was van mening dat er verkeerd gehandeld was.
AV: Hij vertegenwoordigde zijn fractie / fractuur
NV: bekeek

CC: Het pleisterwerk is helemaal grauw en verbrokkeld.
NC: Voor een dergelijk karwei heb je een specialist nodig.
FS : De man begint aan de voorbereidingen voor het moeilijke karwei.
AV: Hij vergruist een stuk kalk / kalf
NV: pakt een stuk

APPENDIX 3

The following Anomalous Verbs were used in the final experiments (where the anomaly was instantiated with respect to both the Competitor and the Actual Word).

Hij streelt een grap / gram
Een van hen kalmeert een bad / bal
Hij groet de stoot / stoom
Hij verbouwt snoep / snoek
Hij beledigt een schop / schok
Zij verrast de harp / hars
Hij onderneemt een tuig / tuit
Hij kauwt de boot / boog
Hij drinkt een strik / strip
Hij vergokte zijn buik / buil
Hij tracteert zijn beurt / beurs
Zij kweken een fuik / fuif
Een van hen verrast de kluif / kluis
Hij commandeert zijn kuit / kuip
Hij verankert de sloot / sloof
Zij bezochten de pek / pet
Hij verkreukelde de blaag / blaam
Het verdroogt de griep / grief
Hij ontslaat de schap / schaft
Hij beklimt de keuze / keutel
Hij mengt de schuif / schuit
Hij verteert het masker / mastiek
Hij verbrandde zijn fractie / fractuur
Hij ondervraagt een stuk kalk / kalf

SAMENVATTING

In dit proefschrift wordt verslag gedaan van een aantal taalpsychologische experimenten over de aard en het tijdsverloop van gesproken woordherkenning. Centraal staat de vraag of semantische informatie het herkenningsproces kan beïnvloeden, waarbij de nadruk ligt op het preciese tijdsmoment van de eventuele beïnvloeding.

Onderzoek naar het tijdsverloop van woordherkenning wordt in de literatuur aangeduid als 'on-line' onderzoek. Dat wil zeggen, het onderzoek richt zich op een karakterisering van de mentale processen die zich milliseconde voor milliseconde afspelen vanaf het begin van de auditieve stimulatie tot aan het moment van herkenning. Het proces van de on-line verwerking van woorden kan worden onderverdeeld in drie relatief onderscheiden functies: toegang, selectie, en integratie. De toegangsfunctie brengt het initiële fysische signaal van een woord in contact met het mentale lexicon en activeert een groep van woordkandidaten die qua fonologische vorm overeenkomen met dat signaal. De selectiefunctie opereert binnen de geactiveerde groep en reduceert het aantal kandidaten tot één, namelijk het feitelijke woord. De integratiefunctie voegt het geselecteerde woord toe aan de betekenisrepresentatie van de zin waarin het woord is ingebed. Deze functionele driedeling van het herkenningsproces laat een nadere precisering toe van de vraag naar het tijdsmoment van een eventueel effect van semantische informatie op woordherkenning. Spelen dergelijke context-effecten zich af tijdens lexicale toegang, selectie, of integratie? Deze vraag ligt ten grondslag aan een slepend debat in de psycholinguïstiek over de aard van het herkenningsproces, waarbij twee klassen van modellen tegenover elkaar staan.

Autonome modellen veronderstellen dat lexicale toegang en selectie zich voltrekken op grond van een samenspel tussen het fysische signaal en de informatie die in het mentale lexicon ligt opgeslagen. Informatie buiten het lexicon, zoals bijvoorbeeld de betekenisrepresentatie van de zinscontext, kan geen invloed uitoefenen op het identificeren van een woord. Op grond van hun aannames over de organisatie van het lexicon kunnen twee soorten autonome modellen worden onderscheiden. Enerzijds zijn er modellen die aannemen dat lexicale selectie uitsluitend aangrijpt op de lexeem-informatie in het lexicon (d.w.z. orthografische en fonologische vormrepresentaties). Anderzijds zijn er modellen die aannemen dat selectie behalve op lexeem-informatie ook op lemma-informatie (d.w.z. semantische representaties) kan aangrijpen.

In tegenstelling tot autonome modellen, veronderstellen interactieve modellen dat in principe alle informatiebronnen die beschikbaar zijn een rol kunnen spelen tijdens het herkenningsproces. Ook hier kan een verdere indeling gemaakt worden. Sommige interactieve modellen stellen dat lexicale toegang en selectie van een woord plaats kunnen vinden reeds voordat er sprake is van fysische stimulatie van dat specifieke woord. Andere modellen stellen dat lexicale toegang uitsluitend op grond van een analyse van het fysische signaal kan gebeuren, en dat pas op het niveau van lexicale selectie alle aanwezige bronnen van informatie benut kunnen worden.

Hoewel er verdere nuanceringen aan te brengen zijn, is het duidelijk dat het meest onderscheidende kenmerk van autonome en interactieve verwerkingsmodellen hun karakterisering is van het lexicale selectieproces. Autonome modellen laten tijdens lexicale selectie geen context-effecten toe die hun oorsprong buiten het mentale lexicon hebben, terwijl interactieve modellen dit wel doen. In een poging om het debat tussen de autonomisten en interactionisten te beslechten, werd in dit proefschrift onderzoek gedaan naar semantische context-effecten tijdens en na lexicale selectie.

Als onderzoeksmethode werd een nieuw paradigma gebruikt, namelijk bimodale kandidaten-priming (een niet al te fraaie vertaling van 'cross-modal candidate priming'). Hierbij wordt auditief een zin aangeboden met aan het eind een zogeheten prime-woord (bijv. "De man kocht een *bad*"). Onmiddelijk na afloop van de auditieve stimulatie wordt visueel een doelwoord aangeboden. Het doelwoord is ofwel gelijk aan het prime-woord (dus: *bad*), ofwel een qua vorm sterk overeenkomend woord (bijv. *bal*). In het eerste geval wordt het visuele woord als het *Feitelijke Woord* aangeduid, in het tweede geval als het *Concurrerende Woord*. Naast de variatie in de relatie tussen het prime-woord en het doelwoord, werd ook de lengte van het aangeboden signaal van het prime-woord gemanipuleerd. Het prime-woord werd of in zijn geheel aangeboden, of er werd slechts een beginsegment aangeboden. Twee in lengte verschillende segmenten werden gebruikt: het *Korte Segment* is dermate meerduidig dat proefpersonen niet kunnen onderscheiden of het Feitelijke Woord wordt aangeboden danwel het Concurrerende Woord; het *Lange Segment* bevat informatie op grond waarvan een voorkeur bestaat voor het Feitelijke Woord, maar het Concurrerende Woord nog steeds niet volledig uitgesloten is. Door middel van het gebruik van deze segmenten wordt geprobeerd om vat te krijgen op de verwerkingsoperaties van het lexicale selectieproces.

De taak voor de proefpersoon was om zodra het visuele doelwoord werd aangeboden deze hardop voor te lezen. Hierbij werd de tijd gemeten tussen aanbieding van het doelwoord en begin van de articulatie. De aanname hierbij is dat de tijd die de proefpersoon nodig heeft om met het uitspreken van het doelwoord te beginnen, zowel een functie is van de mate waarin het doelwoord ondersteund wordt door het signaal van het prime-woord, als van de mate waarin het doelwoord strookt met de voorafgaande context. Indien in situaties waarbij de fysische informatie onvoldoende is om lexicale selectie te bewerkstelligen (i.c. in de segmentcondities), effecten worden waargenomen van de contextuele informatie op de verwerking van de doelwoorden, dan vormt dit evidentie voor interactieve en tegen autonome modellen.

Er werd gekeken naar het verwerkingseffect van twee soorten semantische informatie: lexicale semantiek en zins-semantiek. Het effect van lexicaal-semantische informatie werd onderzocht door het werkwoord direkt voorafgaand aan het prime-woord te variëren. De zogenaamde *Neutrale Werkwoorden* bevatten geen differentiële semantische implicaties voor de doelwoorden (bijv. "De man kocht een *bad/bal*") en dienen als controle conditie voor de *Anomale Werkwoorden*. Deze werkwoorden vormen tezamen met het Concurrerende Woord een semantische schending (bijv. "De man installeerde een *bal*"). De gedachte hierbij is dat indien de lexicaal-semantische informatie een effect uitoefent op de on-line verwerking van het doelwoord, de Anomale Werkwoorden tot een vertraging in de verwerking van Concurrerende Woorden zullen leiden. Een dergelijke vertraging duidt op het gebruik van lexicaal-semantische informatie tijdens woordherkenning en vormt dus evidentie tegen die autonome modellen die uitsluitend effecten van lexeem-representaties voorspellen. Door te kijken naar de modulatie van de eventuele effecten als een functie van de segmentlengten van het prime-woord, kan inzicht worden verkregen op welk moment tijdens de verwerking de invloed van deze informatie zichtbaar wordt.

Het effect van zins-semantiek werd onderzocht door de zins-context voorafgaande aan het prime-woord te variëren. In de *Neutrale Context* waren zowel de Feitelijke Woorden als de Concurrerende Woorden semantisch normale, maar niet voorspelbare eindwoorden (bijv. *"Iedereen was zeer gemotiveerd om er het beste van te maken. De mannen waren de hele dag druk bezig. Een van hen kocht een bad/bal"*). De Neutrale Contexten dienen als controle conditie voor de *Beperkende Contexten* die het Feitelijke Woord een bepaalde mate van voorspelbaarheid geven en het Concurrerende Woord semantisch onwaarschijnlijk maken (bijv. *"Het sanitair in de villa was nodig aan vervanging toe. De mannen waren de hele dag druk bezig. Een van hen kocht een bad/bal"*). Indien zins-semantische informatie gebruikt wordt tijdens de on-line verwerking, dan zal het Feitelijke Woord een positief effect ondervinden van de Beperkende Contexten in vergelijking met de Neutrale Contexten, terwijl het Concurrerende Woord een negatief effect te zien zal geven. Ook hier kan de manipulatie van de lengte van het signaal van het prime-woord inzicht verschaffen in de locatie van dit effect.

Voorafgaand aan de context-experimenten werd een 'draagzin-experiment' afgenomen om het bimodale kandidaten-paradigma en de veronderstelde fonologische verwantschap van de paren van Feitelijke en Concurrerende Woorden te valideren. In dit experiment werden de Korte en Lange Segmenten, alsmede de volledig uitgesproken prime-woorden aangeboden aan het eind van zinnen zoals *"Je gaat nu luisteren naar het woord ..."*. Aangezien deze draagzinnen geen differentieel beperkende informatie bevatten voor de doelwoorden, zijn de benoemingstijden voor deze woorden een weergave van de verwerkingseffecten van de lexicale relatie tussen het prime- en doelwoord, als een functie van toenemende auditieve stimulusinformatie. De data van dit experiment laten zien dat na aanbieding van een Kort Segment zowel Feitelijke als Concurrerende Woorden geactiveerd zijn in het mentale lexicon, en wel in gelijke mate. Deze meervoudige activatie wordt ook waargenomen na aanbieding van een Lang Segment, met daarbij een marginale toename in de activatie van het Feitelijke Woord. Na aanbieding van het volledige prime-woord is het Feitelijke Woord in gelijke mate geactiveerd als na een Lang Segment, terwijl het Concurrerende Woord een significant interferentie-effect vertoont op grond van het lexicale conflict met het prime-woord. Uit de resultaten van het draagzin-experiment kan geconcludeerd worden dat het bimodale kandidaten-paradigma een valide methode is om onderzoek te doen naar de on-line verwerking van gesproken woorden. Tevens blijkt dat de doelwoordparen qua vorm dermate overeenkomen dat zij als mogelijke woordkandidaten simultaan actief zijn tijdens het lexicale selectieproces.

In de eerste twee context-experimenten werd gekeken naar de verwerkingseffecten op de doelwoorden van de boven omschreven lexicaal- en zins-semantische variaties. Er werden significante effecten gevonden van de stimulusinformatie van het prime-woord, alsmede van de relatie van de doelwoorden met het prime-woord, maar geen effect van de contextuele manipulaties. Dit laatste is verbazingwekkend, met name ook omdat zelfs na volledige aanbieding van het prime-woord geen contextuele effecten meetbaar waren. Het verdere onderzoeksprogramma van deze dissertatie probeerde te achterhalen waarom deze nul-effecten werden geobserveerd, waarbij het zoeklicht zich voornamelijk richtte op de werkwoordscontexten.

Als eerste werd getoetst of de hoeveelheid beschikbare verwerkingstijd tussen het einde van de auditieve stimulatie en het aanbieden van het visuele doelwoord een rol speelt. In het eerste onderzoek was dit inter-stimulus interval (ISI) steeds 0 msec. Wellicht is dit onvoldoende tijd om de informationele implicaties van de werkwoordscontexten manifest te laten worden. In een experiment met alleen Neutrale Contexten werd gekeken naar het effect van de Neutrale en Anomale Werkwoorden op de verwerking van de doelwoorden, waarbij een ISI van 100 dan wel 500 msec werd gebruikt. Hoewel er een hoofdeffect gevonden werd voor de ISI-manipulatie, werd wederom geen effect van de werkwoordscontext geregistreerd. Hieruit blijkt dat de tijdsparameters van het eerdere onderzoek niet de bepalende factor waren voor het ontbreken van context-effecten.

Vervolgens werd gekeken naar het effect van semantische schendingen in de auditieve stimulatie. Tot dusver was de werkwoordsmanipulatie alleen gerealiseerd met betrekking tot het Concurrerende Woord. De achterliggende gedachte was dat aangezien het onderzoek zich primair richt op gesproken taalverwerking, het de voorkeur verdient op het niveau van het auditieve signaal geen anomale informatie aan te bieden. Het is echter niet uit te sluiten dat juist daardoor geen werkwoordseffecten werden opgepikt; wellicht dat het meten van benoemingstijden voor Concurrerende Woorden een te indirecte route is om inzicht te krijgen in subtiele lexicale verwerkingseffecten op het niveau van de auditieve stimulatie. Om deze mogelijkheid te onderzoeken werd een nieuwe set van Anomale Werkwoorden geselecteerd die een semantische schending bevatten met betrekking tot zowel het Concurrerende Woord als het Feitelijke Woord. Deze werkwoorden werden tezamen met de al eerder gebruikte Neutrale Werkwoorden in twee experimenten aangeboden, een experiment met Neutrale Contexten en een met Beperkende Contexten. Wederom werden effecten van stimulusinformatie en prime-doelwoord relatie gemeten, maar ook hier kon geen enkel contextueel effect worden geregistreerd, noch voor de werkwoordscontexten, noch voor de zins-contexten.

In het slothoofdstuk wordt allereerst opgemerkt dat het hier gerapporteerde onderzoek evidentie verschaft voor de meervoudige activatie van woordkandiaten tijdens on-line lexicale verwerking. Er wordt gewezen op een aantal bevindingen in de woordherkenningsliteratuur die het voorkomen van fonologische priming tijdens woordherkenning in twijfel trekken, en er wordt besproken waarom deze bevindingen onjuist zijn in het licht van de huidige data. Vervolgens wordt ingegaan op een aantal mogelijke verklaringen voor het ontbreken van context-effecten. Na een bespreking van de validiteit van het materiaal, van het bimodale kandidaten-paradigma, en van de benoemingstaak, wordt geconcludeerd dat het niet aannemelijk is dat een van deze drie factoren afzonderlijk ten grondslag ligt aan de gevonden nul-effecten. Hierna worden twee mogelijke verklaringen besproken die te maken hebben met de verwerkings- en representatie-aannames voor de combinatie van bimodale kandidaten-priming en benoeming. Een mogelijkheid is dat deze specifieke combinatie van paradigma en taak een dermate gering beroep doet op de verwerkingscapaciteit van het taalsysteem, dat de proefpersoon met optimale efficiëntie en snelheid kan handelen, waardoor eventuele differentiële effecten van de experimentele manipulaties niet in de benoemingstijden tot uiting komen. Een tweede mogelijkheid is dat de paradigma-taak combinatie alleen effecten registreerd op het niveau van lexeem-representaties en niet op het niveau van lemma-representaties.

De dissertatie wordt afgesloten met een korte bespiegeling over de psychologische realiteit van autonome versus interactieve modellen in het licht van de gevonden nul-effecten. Beargumenteerd wordt dat de experimentele resultaten een ondersteuning vormen voor autonome modellen. Deze ondersteuning is echter niet zeer overtuigend, aangezien nul-effecten een fragiele empirische basis zijn voor theoretische uitspraken.

Curriculum vitae

Colin Brown werd geboren te Londen maar wist reeds op jonge leeftijd het continent te bereiken. Hij studeerde psychologische functieleer aan de Universiteit van Nijmegen. Naast zijn universitaire studie verrichtte hij van begin 1978 tot eind 1984 taalpsychologisch onderzoek aan het Max-Planck-Institut für Psycholinguistik (MPI) te Nijmegen. In Januari 1985 keerde hij terug naar Engeland waar hij namens het MPI als onderzoeker werkzaam was op een project van de Medical Research Council, achtereenvolgens gehuisvest in het University College te Londen en de Universiteit van Cambridge. In April 1986 aanvaardde hij een driejarig promotiestipendium van de Max-Planck-Gesellschaft zur Förderung der Wissenschaften (München) en streek wederom in Nijmegen neer om aan het MPI het onderzoek uit te voeren waarvan in dit proefschrift verslag wordt gedaan. Sinds Juni 1990 is hij werkzaam op het MPI als projectleider van het project "Brain potentials and language processing: A neurocognitive approach".